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ART. XXXIX.—*Characteristics of the North American Flora: an Address to the Botanists of the British Association for the Advancement of Science at Montreal; read to the Biological Section, August* 29; by ASA GRAY.

WHEN the British Association, with much painstaking, honors and gratifies the cultivators of science on this side of the ocean by meeting on American soil, it is but seemly that a corresponding member for the third of a century should endeavor to manifest his interest in the occasion and to render some service, if he can, to his fellow-naturalists in Section D. I would attempt to do so by pointing out, in a general way, some of the characteristic features of the vegetation of the country which they have come to visit,—a country of "magnificent distances," but of which some vistas may be had by those who can use the facilities which are offered for enjoying them. Even to those who cannot command the time for distant excursions, and to some who may know little or nothing of botany, the sketch which I offer may not be altogether uninteresting. But I naturally address myself to the botanists of the Association, to those who, having crossed the wide Atlantic, are now invited to proceed westward over an almost equal breadth of land; some, indeed, have already journeyed to the Pacific coast, and have returned; and not a few, it is hoped, may accept the invitation to Philadelphia, where a warm welcome awaits them—warmth of hospitality, rather than of summer temperature, let us hope; but Philadelphia is proverbial

for both. There opportunities may be afforded for a passing acquaintance with the botany of the Atlantic border of the United States, in company with the botanists of the American Association, who are expected to muster in full force.

What may be asked of me, then, is to portray certain outlines of the vegetation of the United States and the Canadian Dominion, as contrasted with that of Europe; perhaps also to touch upon the causes or anterior conditions to which much of the actual differences between the two floras may be ascribed. For, indeed, however interesting or curious the facts of the case may be in themselves, they become far more instructive when we attain to some clear conception of the dependent relation of the present vegetation to a preceding state of things, out of which it has come.

As to the Atlantic border on which we stand, probably the first impression made upon the botanist or other observer coming from Great Britain to New England or Canadian shores, will be the similarity of what he here finds with what he left behind. Among the trees the White Birch and the Chestnut will be identified, if not as exactly the same, yet with only slight differences—differences which may be said to be no more essential or profound than those in accent and intonation between the British speech and that of the "Americans." The differences between the Beeches and Larches of the two countries are a little more accentuated; and still more those of the Hornbeams, Elms, and the nearest resembling Oaks. And so of several other trees. Only as you proceed westward and southward will the differences overpower the similarities, which still are met with.

In the fields and along open roadsides the likeness seems to be greater. But much of this likeness is the unconscious work of man, rather than of Nature, the reason of which is not far to seek. This was a region of forest, upon which the aborigines, although they here and there opened patches of land for cultivation, had made no permanent encroachment. Not very much of the herbaceous or other low undergrowth of this forest could bear exposure to the fervid summer's sun; and the change was too abrupt for adaptive modification. The plains and prairies of the great Mississippi Valley were then too remote for their vegetation to compete for the vacancy which was made here when forest was changed to grain-fields and then to meadow and pasture. And so the vacancy came to be filled in a notable measure by agrestial plants from Europe, the seeds of which came in seed-grain, in the coats and fleece and in the imported fodder of cattle and sheep, and in the various but not always apparent ways in which agricultural and commercial people unwittingly convey the plants and ani-

mals of one country to another. So, while an agricultural people displaced the aborigines which the forest sheltered and nourished, the herbs, purposely or accidentally brought with them, took possession of the clearings, and prevailed more or less over the native and rightful heirs to the soil,—not enough to supplant them, indeed, but enough to impart a certain adventitious Old World aspect to the fields and other open grounds, as well as to the precincts of habitations. In springtime you would have seen the fields of this district yellow with European Buttercups and Dandelions, then whitened with the Ox-eye Daisy, and at midsummer brightened by the cærulean blue of Chiccory. I can hardly name any native herbs which *in the fields and at the season* can vie with these intruders in floral show. The common Barberry of the Old World is an early denizen of New England. The tall Mullein, of a wholly alien race, shoots up in every pasture and new clearing, accompanied by the common Thistle, while another imported Thistle, called in the States "the Canada Thistle," has become a veritable nuisance, at which much legislation has been leveled in vain.

According to tradition the wayside Plantain was called by the American Indian "White-Man's foot," from its springing up wherever that foot had been planted. But there is some reason for suspecting that the Indian's ancestors brought it to this continent. Moreover there is another reason for surmising that this long-accepted tradition is factitious. For there was already in the country a native Plantain, so like *Plantago major* that the botanists have only of late distinguished it. (I acknowledge my share in the oversight.) Possibly, although the botanists were at fault, the aborigines may have known the difference. The cows are said to know it. For a brother botanist of long experience tells me that, where the two grow together, cows freely feed upon the undoubtedly native species, and leave the naturalized one untouched.

It has been maintained that the ruderal and agrestial Old World plants and weeds of cultivation displace the indigenous ones of newly-settled countries in virtue of a strength which they have developed through survival in the struggle of ages, under the severe competition incident to their former migrations. And it does seem that most of the pertinacious weeds of the Old World which have been given to us may not be indigenous even to Europe, at least to Western Europe, but belong to campestrine or unwooded regions farther east; and that, following the movements of pastoral and agricultural people, they may have played somewhat the same part in the once forest-clad Western Europe that they have been playing here. But it is unnecessary to build much upon the possibly falla-

cious idea of increased strength gained by competition. Opportunity may count for more than exceptional vigor; and the cases in which foreign plants have shown such superiority are mainly those in which a forest-destroying people have brought upon newly-bared soil the seeds of an open-ground vegetation.

The one marked exception that I know of, the case of recent and abundant influx of this class of Old-World plants into a naturally treeless region, supports the same conclusion. Our associate, Mr. John Ball, has recently called attention to it. The pampas of Southeastern South America beyond the Rio Colorado, lying between the same parallels of latitude in the South as Montreal and Philadelphia in the North, and with climate and probably soils fit to sustain a varied vegetation, and even a fair proportion of forest, are not only treeless, but excessively poor in their herbaceous flora. The district has had no trees since its comparatively recent elevation from the sea. As Mr. Darwin long ago intimated: "Trees are absent not because they cannot grow and thrive, but because the only country from which they could have been derived—tropical and sub-tropical South America—could not supply species to suit the soil and climate." And as to the herbaceous and frutescent species, to continue the extract from Mr. Ball's instructive paper recently published in the Linnean Society's Journal, "in a district raised from the sea during the latest geological period, and bounded on the west by a great mountain range mainly clothed with an alpine flora requiring the protection of snow in winter, and on the north by a warm-temperate region whose flora is mainly of modified sub-tropical origin—the only plants that could occupy the newly-formed region were the comparatively few which, though developed under very different conditions, were sufficiently tolerant of change to adapt themselves to the new environment. The flora is poor, not because the land cannot support a richer one, but because the only regions from which a large population could be derived are inhabited by races unfit for emigration."

Singularly enough, this deficiency of herbaceous plants is being supplied from Europe, and the incomers are spreading with great rapidity; for lack of other forest material even apple-trees are running wild and forming extensive groves. Men and cattle are, as usual, the agents of dissemination. But colonizing plants are filling, in this instance, a vacancy which was left by nature, while ours was made by man. We may agree with Mr. Ball in the opinion that the rapidity with which the intrusive plants have spread in this part of South America "is to be accounted for, less by any special fitness of the immigrant species, than by the fact that the ground is to a great extent unoccupied."

The principle applies here also; and in general, that it is opportunity rather than specially acquired vigor that has given Old-World weeds an advantage may be inferred from the behavior of our weeds indigenous to the country, the plants of the unwooded districts—prairies or savannas west and south,—which, now that the way is open, are coming in one by one into these eastern parts, extending their area continually, and holding their ground quite as pertinaciously as the immigrant denizens. Almost every year gives new examples of the immigration of campestrine western plants into the Eastern States. They are well up to the spirit of the age; they travel by rail-way. The seeds are transported, some in the coats of cattle and sheep on the way to market, others in the food which supports them on the journey, and many in a way which you might not suspect, until you consider that these great roads run east and west, that the prevalent winds are from the west, that a freight-train left unguarded was not long ago blown on for more than one hundred miles before it could be stopped, not altogether on down grades, and that the bared and mostly unkempt borders of these railways form capital seed-beds and nursery grounds for such plants.

Returning now from this side-issue, let me advert to another and, I judge, a very pleasant experience which the botanist and the cultivator may have on first visiting the American shores. At almost every step he comes upon old acquaintances, upon shrubs and trees and flowering herbs, mostly peculiar to this country, but with which he is familiar in the grounds and gardens of his home. Great Britain is especially hospitable to American trees and shrubs. There those both of the eastern and western sides of our continent flourish side by side. Here they almost wholly refuse such association. But the most familiar and longest-established representatives of our flora (certain western annuals excepted) were drawn from the Atlantic coast. Among them are the Virginia Creeper or Ampelopsis, almost as commonly grown in Europe as here, and which, I think, displays its autumnal crimson as brightly there as along the borders of its native woods where you will everywhere meet with it; the Red and Sugar Maples, which give the notable autumnal glow to our northern woods, but rarely make much show in Europe, perhaps for lack of sharp contrast between summer and autumn; the ornamental Ericaceous shrubs, Kalmias, Azaleas, Rhododendrons, and the like, specially called American plants in England, although all the Rhododendrons of the finer sort are half Asiatic, the hardy American species having been crossed and recrossed with more elegant but tender Indian species.

As to flowering herbs, somewhat of the delight with which

an American first gathers wild Primroses and Cowslips and Foxgloves and Daisies in Europe, may be enjoyed by the European botanist when he comes upon our Trilliums and Sanguinaria, Cypripediums and Dodecatheon, our species of Phlox, Coreopsis, etc., so familiar in his gardens; or, when, crossing the continent, he comes upon large tracts of ground yellow with Eschscholtzia or blue with Nemophilas. But with a sentimental difference; in that Primroses, Daisies, and Heaths, like nightingales and larks, are inwrought into our common literature and poetry, whereas our native flowers and birds, if not altogether unsung, have attained at the most to only local celebrity.

Turning now from similarities, and from that which interchange has made familiar, to that which is different or peculiar, I suppose that an observant botanist upon a survey of the Atlantic border of North America (which naturally first and mainly attracts our attention) would be impressed by the comparative wealth of this flora in trees and shrubs. Not so much so in the Canadian Dominion, at least in its eastern part; but even here the difference will be striking enough on comparing Canada with Great Britain.

The Coniferæ, native to the British Islands, are one Pine, one Juniper, and a Yew; those of Canada proper are four or five Pines, four Firs, a Larch, an Arbor-Vitæ, three Junipers, and a Yew,—fourteen or fifteen to three. Of Amentaceous trees and shrubs, Great Britain counts one Oak (in two marked forms), a Beech, a Hazel, a Hornbeam, two Birches, an Alder, a Myrica, eighteen Willows, and two Poplars,—twenty-eight species in nine genera, and under four natural orders. In Canada there are at least eight Oaks, a Chestnut, a Beech, two Hazels, two Hornbeams of distinct genera, six Birches, two Alders, about fourteen Willows and five Poplars, also a Plane tree, two Walnuts and four Hickories; say forty-eight species, in thirteen genera, and belonging to seven natural orders. The comparison may not be altogether fair; for the British flora is exceptionally poor, even for islands so situated. But if we extend it to Scandinavia, so as to have a continental and an equivalent area, the native Coniferæ would be augmented only by one Fir, the Amentaceæ by several more Willows, a Poplar, and one or two more Birches;—no additional orders nor genera.

If we take in the Atlantic United States, east of the Mississippi, and compare this area with Europe, we should find the species and the types increasing as we proceed southward, but about the same numerical proportion would hold.

But, more interesting than this numerical preponderance—which is practically confined to the trees and shrubs—will be the extra-European types, which, intermixed with familiar old-

world forms, give peculiar features to the North American flora,—features discernible in Canada, but more and more prominent as we proceed southward. Still confining our survey to the Atlantic district, that is, without crossing the Mississippi, the following are among the notable points:

1. Leguminous Trees of peculiar types. Europe abounds in leguminous shrubs or under-shrubs, mostly of the Genisteous tribe, which is wanting in all North America, but has no leguminous tree of more pretense than the Cercis and Laburnum. Our Atlantic forest is distinguished by a Cercis of its own, three species of Locust, two of them fine trees, and two Honey Locusts, the beautiful Cladrastis, and the stately Gymnocladus. Only the Cercis has any European relationship. For relatives of the others we must look to the Chino-Japanese region.

2. The great development of the Ericaceæ (taking the order in its widest sense), along with the absence of the Ericeous tribe, that is, of the Heaths themselves. We possess on this side of the Mississippi 30 genera and not far from 90 species. All Europe has only 17 genera and barely 50 species. We have most of the actual European species, excepting their Rhododendrons and their Heaths,—and even the latter are represented by some scattered patches of Calluna, of which it may be still doubtful whether they are chance introductions or sparse and scanty survivals; and besides we have a wealth of peculiar genera and species. Among them the most notable in an ornamental point of view are the Rhododendrons, Azaleas, Kalmias, Andromedas and Clethras; in botanical interest, the endemic Monotropeæ, of which there is only one species in Europe, but seven genera in North America, all but one absolutely peculiar; and in edible as well as botanical interest, the unexampled development and diversification of the genus Vaccinium (along with the allied American type, Gaylussacia) will attract attention. It is interesting to note the rapid falling away of Ericaceæ westward in the valley of the Mississippi as the forest thins out.

3. The wealth of this flora in Compositæ is a most obvious feature; one especially prominent at this season of the year, when the open grounds are becoming golden with Solidago, and the earlier of the autumnal Asters are beginning to blossom. The Compositæ form the largest order of Phænogamous plants in all temperate floras of the northern hemisphere, are well up to the average in Europe, but are nowhere so numerous as in North America, where they form an eighth part of the whole. But the contrast between the Compositæ of Europe and Atlantic North America is striking. Europe runs to Thistles, to Inuloideæ, to Anthemideæ, and to Cichoriaceæ. It has very few Asters and only two Solidagoes, no Sunflowers and hardly anything of that tribe. Our Atlantic flora surpasses all

the world in Asters and Solidagoes, as also in Sunflowers and their various allies, is rich in Eupatoriaceæ, of which Europe has extremely few, and is well supplied with Vernoniaceæ and Helenioideæ of which she has none; but is scanty in all the groups that predominate in Europe. I may remark that if our larger and most troublesome genera, such as Solidago and Aster, were treated in our systematic works even in the way that Nyman has treated Hieracium in Europe, the species of these two genera (now numbering 78 and 124 respectively) would be at least doubled.

4. Perhaps the most interesting contrast between the flora of Europe and that of the eastern border of North America is in the number of generic and even ordinal types here met with which are wholly absent from Europe. Possibly we may distinguish these into two sets of differing history. One will represent a tropical element, more or less transformed, which has probably acquired or been able to hold its position so far north in virtue of our high summer temperature. (In this whole survey the peninsula of Florida is left out of view, regarding its botany as essentially Bahaman and Cuban, with a certain admixture of northern elements.) To the first type I refer such trees and shrubs as Asimina, sole representative of the Anonaceæ out of the tropics, and reaching even to lat. 42°; Chrysobalanus, representing a tropical suborder; Pinckneya representing as far north as Georgia the Cinchoneous tribe; the Baccharis of our coast, reaching even to New England; Cyrilla and Cliftonia, the former actually West Indian; Bumelia, representing the tropical order Sapotaceæ; Bignonia and Tecoma of the Bignoniaceæ; Forestiera in Oleaceæ; Persea of the Laurineæ; and finally the Cactaceæ. Among the herbaceous plants of this set, I will allude only to some of peculiar orders. Among them I reckon Sarracenia (of which the only extra-North American representative is tropical-American, the Melastomaceæ, represented by Rhexia; Passiflora (our species being herbaceous), a few representatives of Loasaceæ and Turneraceæ, also of Hydrophyllaceæ; our two genera of Burmanniaceæ; three genera of Hæmodoraceæ; Tillandsia in Bromeliaceæ; two genera of Pontederiaceæ; two of Commelynaceæ; the outlying Mayaca and Xyris, and three genera of Eriocaulonaceæ. I do not forget that one of our species of Eriocaulon occurs on the west coast of Ireland and in Skye, wonderfully out of place, though on this side of the Atlantic it reaches Newfoundland. It may be a survival in the Old World; but it is more probably of chance introduction.

The other set of extra-European types, characteristic of the Atlantic North American flora, is very notable. According to a view which I have much and for a long while insisted on, it

may be said to represent a certain portion of the once rather uniform flora of the arctic and less boreal zone, from the late Tertiary down to the incoming of the Glacial period, and which, brought down to our lower latitudes by the gradual refrigeration, has been preserved here in eastern North America and in the corresponding parts of Asia, but was lost to Europe. I need not recapitulate the evidence upon which this now generally accepted doctrine was founded; and to enumerate the plants which testify in its favor would amount to an enumeration of the greater part of the genera or subordinate groups of plants which distinguish our Atlantic flora from that of Europe. The evidence, in brief, is that the plants in question, or their moderately differentiated representatives, still co-exist in the flora of eastern North America and that of the Chino-Japanese region, the climates and conditions of which are very similar; and that the fossilized representatives of many of them have been brought to light in the late tertiary deposits of the arctic zone wherever explored. In mentioning some of the plants of this category I include the Magnolias, although there are no nearly identical species, but there is a seemingly identical Liriodendron in China, and the Schizandras and Illiciums are divided between the two floras; and I put into the list Menispermum, of which the only other species is eastern Siberian, and is hardly distinguishable from ours. When you call to mind the series of wholly extra-European types which are identically or approximately represented in the eastern North American and in the eastern Asiatic temperate floras, such as Trautvetteria and Hydrastis in Ranunculaceæ; Caulophyllum, Diphylleia, Jeffersonia and Podophyllum in Berberideæ; Brasenia and Nelumbium in Nymphæaceæ; Stylophorum in Papaveraceæ; Stuartia and Gordonia in Ternstromiaceæ; the equivalent species of Xanthoxylum, the equivalent and identical species of Vitis, and of the poisonous species of Rhus (one, if not both, of which you may meet with in every botanical excursion, and which it will be safer not to handle); the Horse-chestnuts, here called Buckeyes; the Negundo, a peculiar offshoot of the Maple tribe; when you consider that almost every one of the peculiar Leguminous trees mentioned as characteristic of our flora is represented by a species in China or Manchuria or Japan, and so of some herbaceous Leguminosæ; when you remember that the peculiar small order of which Calycanthus is the principal type has its other representative in the same region; that the species of Philadelphus, of Hydrangea, of Itea, Astilbe, Hamamelis, Diervilla, Triosteum, Mitchella which carpets the ground under evergreen woods, Chiogenes, creeping over the shaded bogs; Epigæa, choicest woodland flower of early spring; Elliottia; Shortia (the curious history

of which I need not rehearse); Styrax of cognate species; Nyssa, the Asiatic representatives of which affect a warmer region; Gelsemium, which under the name of Jessamine is the vernal pride of the Southern Atlantic States; Pyrularia and Buckleya, peculiar Santalaceous shrubs; Sassafras and Benzoins of the Laurel family; Planera and Maclura; Pachysandra of the Box tribe; the great development of the Juglandaceæ (of which the sole representative in Europe probably was brought by man into southeastern Europe in pre-historic times); our Hemlock-Spruces, Arbor-vitæ, Chamæcyparis, Taxodium and Torreya, with their East Asian counterparts, the Roxburghiaceæ, represented by Croomia—and I might much further extend and particularize the enumeration—you will have enough to make it clear that the peculiarities of the one flora are the peculiarities of the other, and that the two are in striking contrast with the flora of Europe.

This contrast is susceptible of explanation. I have ventured to regard the two antipodal floras thus compared as the favored heirs of the ante-glacial high northern flora, or rather as the heirs who have retained most of their inheritance. For, inasmuch as the present arctic flora is essentially the same round the world, and the Tertiary fossil plants entombed in the strata beneath are also largely identical in all the longitudes, we may well infer that the ancestors of the present northern temperate plants were as widely distributed throughout their northern home. In their enforced migration southward geographical configuration and climatic differences would begin to operate. Perhaps the way into Europe was less open than into the lower latitudes of America and eastern Asia, although there is reason to think that Greenland was joined to Scandinavia. However that be, we know that Europe was fairly well furnished with many of the vegetable types that are now absent, possibly with most of them. Those that have been recognized are mainly trees and shrubs, which somehow take most readily to fossilization, but the herbaceous vegetation probably accompanied the arboreal. At any rate, Europe then possessed Torreyas and Gingkos, Taxodium and Glyptostrobus, Libocedrus, Pines of our five-leaved type, as well as the analogues of other American forms, several species of Juglans answering to the American forms, and the now peculiarly American genus Carya, Oaks of the American types, Myricas of the two American types, one or two Planer-trees, species of Populus answering to our Cotton-woods and our Balsam-poplar, a Sassafras and the analogues of our Persea and Benzoin, a Catalpa, Magnolias and a Liriodendron, Maples answering to ours, and also a Negundo, and such peculiarly American Leguminous genera as the Locust, Honey Locust, and Gymnocladus. To

understand how Europe came to lose these elements of her flora, and Atlantic North America to retain them, we must recall the poverty of Europe in native forest trees, to which I have already alluded. A few years ago, in an article on this subject, I drew up a sketch of the relative richness of Europe, Atlantic North America, Pacific North America and the eastern side of temperate Asia in genera and species of forest trees.* In that sketch, as I am now convinced, the European forest-elements were somewhat under-rated. I allowed only 33 genera and 85 species, while to our Atlantic American forest were assigned 66 genera and 155 species. I find from Nyman's Conspectus that there are trees on the southern and eastern borders of Europe which I had omitted, that there are good species which I had reckoned as synonyms, and some that may rise to arboreal height which I had counted as shrubs. But on the other hand and for the present purpose it may be rejoined that the list contained several trees, of as many genera, which were probably carried from Asia into Europe by the hand of man. On Nyman's authority I may put into this category Cercis Siliquastrum, Ceratonia Siliqua, Diospyros Lotus, Styrax officinalis, the Olive, and even the Walnut, the Chestnut, and the Cypress. However this may be, it seems clear that the native forest flora of Europe is exceptionally poor, and that it has lost many species and types which once belonged to it. We must suppose that the herbaceous flora has suffered in the same way. I have endeavored to show how this has naturally come about. I cannot state it more concisely than in the terms which I used six years ago.

"I conceive that three things have conspired to this loss of American, or as we might say, of normal types sustained by Europe. First, Europe, extending but little south of lat. 40°, is all within the limits of severe glacial action. Second, its mountains trend east and west, from the Pyrenees to the Carpathians and the Caucasus beyond: they had glaciers of their own, which must have begun their work and poured down the northward flanks while the plains were still covered with forest on the retreat from the great ice forces coming from the north. Attacked both on front and rear, much of the forest must have perished then and there.

"Third, across the line of retreat of whatever trees may have flanked the mountain ranges, or were stationed south of them, stretched the Mediterranean, an impassible barrier. . . Escape by the east, and rehabilitation from that quarter until a very late period, was apparently prevented by the prolongation of the Mediterranean to the Caspian, and probably thence to the Siberian Ocean. If we accept the supposition of Norden-

* This Journal, III, xvi, 85.

skiöld that, anterior to the Glacial period, Europe was 'bounded on the south by an ocean extending from the Atlantic over the present deserts of Sahara and Central Asia to the Pacific,' all chance of these American types having escaped from and reëntered Europe from the south and east seems excluded. Europe may thus be conceived to have been for a time somewhat in the condition in which Greenland is now. . . . Greenland may be referred to as a country which, having undergone extreme glaciation, bears the marks of it in the extreme poverty of its flora, and in the absence of the plants to which its southern portion, extending six degrees below the arctic circle, might be entitled. It ought to have trees and it might support them. But since their destruction by glaciation no way has been open for their return. Europe fared much better, but has suffered in its degree in a similar way."*

Turning to this country for a contrast, we find the continent on the eastern side unbroken and open from the arctic circle to the tropic, and the mountains running north and south. The vegetation when pressed on the north by on-coming refrigeration had only to move its southern border southward to enjoy its normal climate over a favorable region of great extent; and, upon the recession of glaciation to the present limit, or in the oscillations which intervened, there was no physical impediment to the adjustment. Then, too, the more southern latitude of this country gave great advantage over Europe. The line of terminal moraines, which marks the limit of glaciation rarely passes the parallel of 40° or 39°. Nor have any violent changes occurred here, as they have on the Pacific side of the continent, within the period under question. So, while Europe was suffering hardship, the lines of our Atlantic American flora were cast in pleasant places, and the goodly heritage remains essentially unimpaired.

The transverse direction and the massiveness of the mountains of Europe, while they have in part determined the comparative poverty of its forest-vegetation, have preserved there a rich and widely distributed alpine flora. That of Atlantic North America is insignificant. It consists of a few arctic plants, left scattered upon narrow and scattered mountain-tops, or in cool ravines of moderate elevation; the maximum altitude is only about 6,000 feet in lat. 44°, on the White Mountains of New Hampshire, where no winter snow outlasts midsummer. The best alpine stations are within easy reach of Montreal. But as almost every species is common to Europe, and the mountains are not magnificent, they offer no great attraction to a European botanist.

Farther south, the Appalachian Mountains are higher, be-

* This Journal, l. c., 194.

tween lat. 36° and 34° rising considerably above 6,000 feet; they have botanical attractions of their own, but they have no alpine plants. A few subalpine species linger on the cool shores of Lake Superior, at a comparatively low level. Perhaps as many are found nearly at the level of the sea on Anticosti, in the Gulf of St. Lawrence, abnormally cooled by the Labrador current.

The chain of great fresh-water lakes, which are discharged by the brimming St. Lawrence, seems to have little effect upon our botany, beyond the bringing down of a few northwestern species. But you may note with interest that they harbor sundry maritime species, mementoes of the former saltness of these interior seas. Cakile Americana, much like the European Sea Rocket, Hudsonia tomentosa (a peculiar Cistaceous genus imitating a Heath), Lathyrus maritimus, and Ammophila arenaria are the principal. Salicornia, Glaux, Scirpus maritimus, Ranunculus Cymbalaria, and some others may be associated with them. But these are widely diffused over the saline soil which characterizes the plains beyond our wooded region.

I have thought that some general considerations like these might have more interest for the biological section at large than any particular indications of our most interesting plants, and of how and where the botanist might find them. Those who in these busy days can find time to herborize will be in the excellent hands of the Canadian botanists. At Philadelphia their brethren of "the States" will be assembled to meet their visitors, and the Philadelphians will escort them to their classic ground, the Pine Barrens of New Jersey. To have an idea of this peculiar phytogeographical district, you may suppose a long wedge of the Carolina coast to be thrust up northward quite to New York harbor, bringing into a comparatively cool climate many of the interesting low-country plants of the South, which, at this season, you would not care to seek in their sultry proper home. Years ago, when Pursh and Leconte and Torrey used to visit it, and in my own younger days, it was wholly primitive and unspoiled. Now, when the shore is lined with huge summer hotels, the Pitch Pines carried off for firewood, the bogs converted into cranberry-grounds, and much of the light sandy or gravely soil planted with vineyards or converted into melon and sweet-potato patches, I fear it may have lost some of its botanical attractions. But large tracts are still nearly in a state of nature. Drosera filiformis, so unlike any European species, and the beautiful Sabbatias, the yellow Fringed Orchises, Lachnanthes and Lophiola, the larger Xyrises and Eriocaulons, the curious grass Amphicarpum with cleistogamous flowers at the root, the showy species of Chrysopsis, and many others, must still abound. And every botanist

will wish to collect Schizæa pusilla, rarest, most local, and among the smallest of Ferns.

If only the season would allow it, there is a more southern station of special interest,—Wilmington, on the coast of North Carolina. Carnivorous plants have, of late years, excited the greatest interest, both popular and scientific, and here, of all places, carnivorous plants seem to have their most varied develment. For this is the only and the very local home of Dionæa; here grow almost all the North American species of Drosera; here or near by are most of the species of Sarracenia, of the bladder-bearing Utricularias,—one of which the President of our Section has detected in fish-catching,—and also the largest species of Pinguicula.

But at this season a more enjoyable excursion may be made to the southern portion of the Alleghany or Appalachian Mountains, which separate the waters of the Atlantic side from those of the Mississippi. These mountains are now easily reached from Philadelphia. In Pennsylvania, where they consist of parallel ridges without peaks or crests, and are of no great height, they are less interesting botanically than in Virginia; but it is in North Carolina and the adjacent borders of Tennessee that they rise to their highest altitude, and take on more picturesque forms. On their sides the Atlantic forest, especially its deciduous-leaved portion, is still to be seen to greatest advantage, nearly in pristine condition, and composed of a greater variety of genera and species than in any other temperate region, excepting Japan. And in their shade are the greatest variety and abundance of shrubs, and a good share of the most peculiar herbaceous genera. This is the special home of our Rhododendrons, Azaleas, and Kalmias; at least here they flourish in greatest number and in most luxuriant growth. Rhododendron maximum (which is found in a scattered way even as far north as the vicinity of Montreal) and Kalmia latifolia (both called Laurels) even become forest trees in some places; more commonly they are shrubs, forming dense thickets on steep mountain-sides, through which the traveler can make his way only by following old bear-paths, or by keeping strictly on the dividing crests of the leading ridges.

Only on the summits do we find Rhododendron Catawbiense, parent of so many handsome forms in English grounds, and on the higher wooded slopes the yellow and the flame-colored Azalea calendulacea; on the lower, the pink A. nudiflora and more showy A. arborescens, along with the common and widespread A. viscosa. The latter part of June is the proper time to explore this region, and, if only one portion can be visited, Roan Mountain should be preferred.

On these mountain tops we meet with a curious anomaly in

geographical distribution. With rarest exceptions, plants which are common to this country and to Europe extend well northward. But on these summits from southern Virginia to Carolina, yet nowhere else, we find—undoubtedly indigenous and undoubtedly identical with the European species—the Lily-of-the-Valley!

I have given so much of my time to the botany of the Atlantic border that I can barely touch upon that of the western regions.

Between the wooded country of the Atlantic side of the continent and that of the Pacific side lies a vast extent of plains which are essentially woodless, except where they are traversed by mountain-chains. The prairies of the Atlantic States bordering the Mississippi and of the Winnipeg country shade off into the drier and gradually more saline plains, which, with an even and gradual rise, attain an elevation of 5,000 feet or more where they abut against the Rocky Mountains. Until these are reached (over a space from the Alleghanies westward of about twenty degrees of longitude) the plains are unbroken. To a moderate distance beyond the Mississippi the country must have been in the main naturally wooded. There is rainfall enough for forest on these actual prairies. Trees grow fairly well when planted; they are coming up spontaneously under present opportunities; and there is reason for thinking that all the prairies east of the Mississippi, and of the Missouri up to Minnesota, have been either greatly extended or were even made treeless under Indian occupation and annual burnings. These prairies are flowery with a good number of characteristic plants, many of them evidently derived from the plains farther west. At this season, the predominant vegetation is of Compositæ, especially of Asters and Solidagoes, and of Sunflowers, Silphiums, and other Helianthoid Compositæ.

The drier and barer plains beyond, clothed with the short Buffalo-Grasses, probably never bore trees in their present state, except as now some Cottonwoods (i. e. Poplars) on the margins of the long rivers which traverse them in their course from the Rocky Mountains to the Mississippi. Westward, the plains grow more and more saline; and Wormwoods and Chenopodiaceæ of various sorts form the dominant vegetation, some of them *sui generis* or at least peculiar to the country, others identical or congeneric with those of the steppes of northern Asia. Along with this common campestrine vegetation, there is a large infusion of peculiar American types, which I suppose came from the southward, and to which I will again refer.

Then come the Rocky Mountains, traversing the whole continent from north to south; their flanks wooded, but not richly so,—chiefly with Pines and Firs of very few species, and with

a single ubiquitous Poplar, their higher crests bearing a well-developed alpine flora. This is the arctic flora prolonged southward upon the mountains of sufficient elevation, with a certain admixture in the lower latitudes of types pertaining to the lower vicinity.

There are almost 200 alpine Phænogamous species now known on the Rocky Mountains; fully three-quarters of which are arctic, including Alaskan and Greenlandian; and about half of them are known in Europe. Several others are North Asian but not European. Even in that northern portion of the Rocky Mountains which the Association is invited to visit, several alpine species novel to European botany may be met with; and farther south the peculiar forms increase. On the other hand, it is interesting to note how many Old-World species extend their range southward even to lat. 36° or 35°.

I have not seen the Rocky Mountains in the Dominion; but I apprehend that the aspect and character of the forest is Canadian, is mainly coniferous, and composed of very few species. Oaks and other cupuliferous trees, which give character to the Atlantic forest, are entirely wanting, until the southern confines of the region are reached in Colorado and New Mexico, and there they are few and small. In these southern parts there is a lesser amount of forest, but a much greater diversity of genera and species; of which the most notable are the Pines of the Mexican plateau type.

The Rocky Mountains and the Coast Ranges on the Pacific side so nearly approach in British America that their forests merge, and the eastern types are gradually replaced by the more peculiar western. But in the United States a broad, arid and treeless, and even truly desert region is interposed. This has its greatest breadth and is best known where it is traversed by the Central Pacific Railroad. It is an immense plain between the Rocky Mountains and the Sierra Nevada, largely a basin with no outlet to the sea, covered with Sage-brush (i. e. peculiar species of Artemisia) and other subsaline vegetation, all of grayish hue; traversed, mostly north and south, by chains of mountains, which seem to be more bare than the plains, but which hold in their recesses a considerable amount of forest and of other vegetation, mostly of Rocky Mountain types.

Desolate and desert as this region appears, it is far from uninteresting to the botanist; but I must not stop to show how. Yet even the ardent botanist feels a sense of relief and exultation when, as he reaches the Sierra Nevada, he passes abruptly into perhaps the noblest coniferous forest in the world,—a forest which stretches along this range and its northern continuation, and along the less elevated ranges which border the Pacific coast, from the southern part of California to Alaska.

So much has been said about this forest, about the two gigantic trees which have made it famous, and its Pines and Firs which are hardly less wonderful, and which in Oregon and British Columbia, descending into the plains, yield far more timber to the acre than can be found anywhere else, and I have myself discoursed upon the subject so largely on former occasions, that I may cut short all discourse upon the Pacific coast flora and the questions it brings up.

I note only these points. Although this flora is richer than that of the Atlantic in Coniferæ (having almost twice as many species), richer indeed than any other except that of Eastern Asia, it is very meagre in deciduous trees. It has a fair number of Oaks, indeed, and it has a Flowering Dogwood, even more showy than that which brightens our eastern woodlands in spring. But, altogether it possesses only one-quarter of the number of species of deciduous trees that the Atlantic forest has; it is even much poorer than Europe in this respect. It is destitute not only of the characteristic trees of the Atlantic side, such as Liriodendron, Magnolia, Asimina, Nyssa, Catalpa, Sassafras, Carya, and the arboreous Leguminosæ (Cercis excepted), but it also wants most of the genera which are common throughout all the other northern-temperate floras, having no Lindens, Elms, Mulberries, Celtis, Beech, Chestnut, Hornbeam, and few and small Ashes and Maples. The shrubbery and herbaceous vegetation, although rich and varied, is largely peculiar, especially at the south. At the north we find a fair number of species identical with the eastern; but it is interesting to remark that this region, interposed between the N. E. Asiatic and the N. E. American and with coast approximate to the former, has few of those peculiar genera which, as I have insisted, witness to a most remarkable connection between two floras so widely sundered geographically. Some of these types, indeed, occur in the intermediate region, rendering the general absence the more noteworthy. And certain peculiar types are represented in single identical species on the coasts of Oregon and Japan, etc., (such as Lysichiton, Fatsia, Glehnia); yet there is less community between these floras than might be expected from their geographical proximity at the north. Of course the high northern flora is not here in view.

Now if, as I have maintained, the eastern side of North America and the eastern side of Northern Asia are the favored heirs of the old boreal flora, and if I have plausibly explained how Europe lost so much of its portion of a common inheritance, it only remains to consider how the western side of North America lost so much more. For that the missing types once existed there, as well as in Europe, has already been in-

dicated in the few fossil explorations that have been made. They have brought to light Magnolias, Elms, Beeches, Chestnut, a Liquidambar, etc. And living witnesses remain in the two Sequoias of California, whose ancestors, along with Taxodium, which is similarly preserved on the Atlantic side, appear to have formed no small part of the Miocene flora of the arctic regions.

Several causes may have conspired in the destruction;—climatic differences between the two sides of the continent, such as must early have been established (and we know that a difference no greater than the present would be effective); geographical configuration, probably confining the migration to and fro to a long and narrow tract, little wider, perhaps, than that to which it is now restricted; the tremendous outpouring of lava and volcanic ashes just anterior to the Glacial period, by which a large part of the region was thickly covered; and, at length competition from the Mexican plateau vegetation,—a vegetation beyond the reach of general glacial movement from the north, and climatically well adapted to the southwestern portion of the United States.

It is now becoming obvious that the Mexican plateau vegetation is the proximate source of most of the peculiar elements of the Californian flora, as also of the southern Rocky Mountain region and of the Great Basin between; and that these plants from the south have competed with those from the north on the eastward plains and prairies. It is from this source that are derived not only our Cacteæ but our Mimoseæ, our Daleas and Petalostemons, our numerous and varied Onagraceæ, our Loasaceæ, a large part of our Compositæ, especially the Eupatoriaceæ, Helianthoideæ, Helenioideæ, and Mutisiaceæ, which are so characteristic of the country, the Asclepiadeæ, the very numerous Polemoniaceæ, Hydrophyllaceæ, Eriogoneæ, and the like.

I had formerly recognized this element in our North American flora; but I have only recently come to apprehend its full significance. With increasing knowledge we may in a good measure discriminate between the descendants of the ancient northern flora, and those which come from the highlands of the southwest.

ART. XL.—*Columbite in the Black Hills of Dakota;* by WM. P. BLAKE.

COLUMBITE associated with cassiterite, albite and mica occurs in several of the coarsely crystalline granite dikes which traverse the mica schists and sandstones of Pennington County,

Dakota. The most notable localities are at the Etta mining claim and at the Ingersoll, about ten miles east of Harney Peak. At the Ingersoll claim, particularly, a mass of unusual dimensions was found protruding from a matrix of albite and quartz. This mass consisted of nearly pure columbite with here and there inclusions of thin sheets of quartz. It measured, approximately, twenty inches square by twenty-four in length, weighing by calculation, taking the specific gravity at 6, not less than 2000 pounds, or one ton. On blasting it out it broke up generally into tabular fragments without crystalline planes except at the lower or imbedded end where it was enclosed in quartz, into which it penetrated in thin, tabular crystals with brilliant prismatic and terminal planes. At the Etta on the contrary, the best crystals are taken from the albite and are more distinct and separate than at the Ingersoll claim. The habit of the Ingersoll crystals is thin and tabular with acute, wedge-like prismatic edges; the plane $i\text{-}\bar{2}$ being nearly obliterated by the extension of the planes $i\text{-}\bar{3}$ and I, while at the Etta these planes are subordinate to the plane $i\text{-}\bar{2}$ and $i\text{-}\bar{2}$. The terminal plane O is generally narrow in the crystals from both localities, and is flanked by a series of bevelling planes like those in the Greenland crystals, $\frac{1}{3}\text{-}\bar{2}$ being especially prominent.

In breaking up the large mass I found several cavities filled with a beautiful yellow powder often in pellets and pill-like balls. These prove to be chiefly hydrous uranium oxide without sulphuric or carbonic acid. A similar mineral occurs at the Etta but gives different reactions.

The blow-pipe reactions of the columbite from the Ingersoll claim are peculiar in the amount of manganese indicated. With borax, in O.F. the bead is dark amethystine red, and in R.F. a pale amber yellow. The purity of this reaction for manganese is not impaired by any other metallic reaction. With phosphate of soda and ammonia in O.F. the mineral dissolves to a clear glass, red while hot, yellowish-red while cooling, and when cold clear and nearly colorless, with a pale rose-colored or amethystine tint. In R.F. the bead is beautiful amber-yellow and there is no shade of green or reaction for uranium. On foil the manganese reaction is distinct. Treated with concentrated sulphuric acid and evaporated to dryness the powdered mineral is partially decomposed. With the addition of a second portion of acid the solution gives with zinc the intense sapphire-blue reaction.

Pine Forest Camp, September 25, 1884.

ART. XLI.—*A Spectro-photometric Study of Pigments;* by EDWARD L. NICHOLS, Ph.D.

[Read at the Philadelphia meeting of the American Association for the Advancement of Science.]

THE usual methods of determining the three so-called constants of color—hue, purity and luminosity—are open to serious question. If the light reflected by pigments were nearly monochromatic, the comparison of their colors with the tints of the solar spectrum would offer no difficulty and the wave-length would afford a most convenient measure of the hue. The spectroscope shows, however, that pigments cannot be considered even in the roughest approximation as reflecting monochromatic light. They exhibit continuous spectra in which are present a large proportion of the rays of the visible spectrum of white light. They do not owe their color to the presence of well defined bright lines or bands, nor to the absence of particular wave-lengths, but to the manner in which the intensity of different portions of their spectra varies with the wave-length. Their color is much more nearly akin to white, of which indeed it may very properly be considered a modification, than it is to any monochromatic tint, and the attempt to compare the combined effect of all the rays reflected to the eye by a pigment with that produced by any single wave-length of the solar spectrum cannot but prove unsatisfactory. It is often possible, nevertheless, to decide upon a particular region as matching the pigment more nearly than any other, but owing to the difference in eyes all observers do not select the same wave-length and the comparison serves better to exhibit peculiarities of color-perception than to indicate the character of the pigment.

It is found that by mixing with white light the portion of the spectrum corresponding most nearly to a pigment in hue, the resemblance is increased. The purity of the pigment is determined by the amount of white light which gives the nearest approach to identity; to which amount under the usual, but untenable, assumption that the light reflected by pigments is a mixture of white and monochromatic light, it is in inverse proportion.

The usual method of determining the luminosity is even more questionable. That the brightness of two surfaces is comparable only when they are of the same color is a universally accepted principle in photometry. Even slight differences of tint introduce an element of uncertainty, and methods which involve the comparison of a neutral gray surface with those

presented by deeply tinted pigments cannot but be regarded with doubt.

It may be urged in favor of the use of these three constants of color that the methods just alluded to have led to fairly accordant results, have increased very much our knowledge of the properties of pigments, and have given us a means of describing colors and distinguishing between them which however artificial and faulty cannot well be dispensed with. If the subject were such as to preclude the adoption of a more scientific and complete method of determining the character of the light reflected by non-luminous bodies, there would be less force to the objections just offered to the present system. The question of a better method is however not so complex as it may seem at first sight. It resolves itself from the nature of the case into a perfectly definite problem; to determine what wave-lengths are present in the spectrum of the light reflected by the object in question, and to measure the intensity of each wave-length.

The use of the spectroscope in mapping spectra leaves nothing to be desired in the determination of the wave-length, the methods in vogue in the study of absorption spectra being equally adapted to the investigation of the reflected rays. The addition to the spectroscope of parts which shall make it possible to measure the intensity of all portions of a spectrum as readily as we determine the wave-length, will enable us to substitute for the present system of questionable color-constants a perfectly definite and complete statement of the wave-length and intensity of the rays emanating from any object whether viewed by transmitted or by reflected light.

An instrument which fulfills these requirements is a modification of the spectro-photometer used by the writer in 1878 in the study of the spectrum of glowing platinum.[1] Like the spectro-photometers of Vierordt[2] and Glan[3] it depends upon the sensitiveness of the eye to small differences in the brightness of neighboring surfaces of identical color; a property which enables the observer to decide with great certainty when two portions of a field of view, which is of one tint throughout, but the two halves of which can be varied in intensity at will, are equally bright.

In front of the slit of an ordinary one-prism spectroscope (see fig. 1) a right angled prism (P) is placed, with its edge perpendicular to the slit (S) and bisecting it, and its longest face extending downward and outward at an angle of 45.°

[1] Ueber das von glühendem Platin ausgestrahlte Licht, Göttingen 1879. Also this Journal, Dec. 1879 and Jan., 1880.

[2] Vierordt, Poggendorff's Annalen, vol. cxl.

[3] Glan, Wiedemann's Annalen, vol. i.

Rays coming vertically from below this prism are totally reflected by it and pass through the lower half of the slit, the collimator and the dispersing prism of the spectroscope. The light reflected from any object placed beneath the reflecting prism thus produces a spectrum, which occupies the upper half of the field of view of the inverting telescope. Before the upper half of the slit is placed a Nicol's prism (N) with the longer

1.

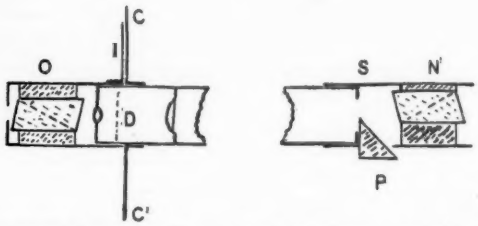


Diagram showing the eye-piece and slit of the spectro-photometer, with the adjoining parts.

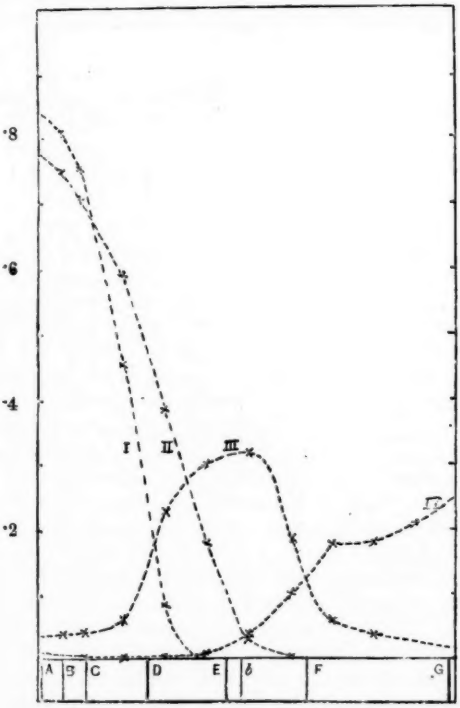
diagonals of its faces vertical, the optical axis being parallel to the axis of the collimator tube. Light passing through this Nicol and through the upper half of the slit, the collimator and dispersing prism forms a spectrum just below the first one (in the field of view). The boundary between the two spectra is the sharply defined image of the edge of the reflecting prism where it bisects the slit. The second spectrum is polarized in a vertical plane: the first one is unpolarized. A diaphragm (D) in the eye-piece of the spectroscope, by means of which vision may be confined to the region under observation, and a second Nicol (O), next the eye, complete the spectro-photometer. The second or "ocular Nicol" is free to revolve, and its position is indicated by a pointer (I) moving upon a graduated circle (C).

In order to compare the spectrum of the light reflected by any object with the spectrum of daylight, the object is placed below the reflecting prism and illuminated either by the direct rays of the sun or by diffuse daylight. Before the polarizing Nicol a white sheet of paper or a plane mirror reflecting light from the sky, furnishes the polarized spectrum. It is possible by rotating the ocular Nicol to give this spectrum any intensity between that which it possesses when the polarizing planes of the two Nicols are parallel and that at which it becomes too faint to be visible. Whatever be the character of the light reflected by the object to be studied, it is therefore possible to find a position of the ocular Nicol for which the region of the spectrum under observation and the corresponding wave-length of the polarized spectrum are equally bright. From the angle

between the planes of polarization of the two Nicols can then be calculated the ratio between the intensities of the two spectral regions when the polarized spectrum is at its maximum; and a series of measurements of the variation of the intensity with the wave-length may be obtained, in which the intensity of each region is expressed in terms of the intensity of the corresponding wave-length in the spectrum of daylight.

In studying the spectra of a variety of substances it is necessary, in order to bring them to a common scale, to adopt some

2.



Curves showing the intensity of the spectra of four pigments (I, red lead; II, chromate of lead; III, chromic oxide; IV, ultramarine). Abscissæ are wave-lengths. Ordinates are intensities.

standard of color and of luminosity; for which purpose a pigment presenting a neutral white surface is most suitable. By comparing the spectrum of this white surface with the polarized spectrum under precisely the same conditions as those

under which each pigment is compared, all measurements can be referred to a common unit, i. e. to the intensity of a certain region of this spectrum; or, as is generally more convenient, each region in the spectra of the pigments can be referred to the intensity of the corresponding wave-length in this standard spectrum.

To test the efficacy of this method four characteristic pigments were selected. These were red-lead, chromate of lead, chromic oxide and artificial ultramarine. The red and blue were the usual commercial preparations. They showed well formed crystals under the microscope. The yellow and green were freshly prepared by precipitation and the separate parti-

TABLE.

Region.		Intensity referred to that of the corresponding wave-length of the spectrum of white light.				Intensity referred to that of the region of the D line in the spectrum of white light.				
Color. (Rood.*)	Wave-length.	Red lead.	Chromate of lead.	Chromic oxide.	Ultramarine.	Red lead.	Chromate of lead.	Chromic oxide.	Ultramarine.	White. (Lamansky.)†
Red,	6800	0·815	0·744	0·042	....	1·158	1·056	0·060	....	1·421
Orange-red,	6550	0·747	0·718	0·046	0·005	0 996	0·957	0·062	0·007	1·333
Orange,	5950	0·452	0·587	0·061	0·004	0·515	0·670	0 068	0·005	1·114
Yellow,	5680	0·077	0·371	0·023	0·006	0 073	0·352	0·211	0·005	0·947
Yellow-green,	5370	....	0·170	0·297	0·009	....	0·132	0·232	0·006	0·781
Green,	5200	....	0·026	0·322	0·034	....	0·017	0·225	0·021	0·649
Green-blue,	4910	....	0·001	0·184	0·110	....	0·001	0·092	0·055	0·500
Cyan-blue,	4700	....	....	0·064	0·181	..	....	0·026	0·072	0·400
Blue,	4580	....	....	0·045	0·182	....	....	0·013	0·055	0·303
Violet-blue,	4410	....	....	....	0·210	....	....	....	0·047	0·225
Violet,	4330	....	....	....	....	....	....	....	....	0·106

* Rood, Modern Chromatics, p. 26. † Lamansky (article already cited).

cles could not be distinguished with a $\frac{1}{4}$ inch objective. These dry pigments were spread to a depth of about 10^{mm} upon a black surface. They were not subjected to any considerable pressure. Powdered magnesium carbonate treated in the same manner served as the standard white. The spectrum of the light reflected from the rather uneven surfaces thus obtained was compared with the spectrum of daylight. The measurements, the results of which are exhibited in the above table and by the accompanying curves (figure 2) were made for the most part by the writer's assistant, Mr. W. S. Franklin. Each value is the mean of ten or more readings. The portions of the spectrum in which measurements were made are designated by their characteristic colors. The wave-lengths are

given in ten millionths of a millimeter. The first set of values given in the table are referred to the corresponding intensities of the standard spectrum; the second set are all referred to the intensity of the region of the D line in the standard spectrum, the well known measurements of the intensities of the solar-spectrum by Lamansky[1] being used in the reduction.

The curves (figure 2) accompanying the foregoing table represent graphically the results of this method as applied to the four pigments in question. The abscissæ are wave-lengths, the ordinates are intensities and the curves show the distribution of energy throughout the prismatic spectrum. They are identical with the curves which would be obtained by exploring the spectra of the pigments with a sufficiently delicate thermopile, and do not represent the optical effect which is a complicated function of the energy of the ray, the character of which is not the same for all wave-lengths nor for all eyes. An inspection of these curves verifies the opinion expressed in the first paragraph of this paper, that pigments are more nearly related to white than to any monochromatic color, and that the attempt to express the hue of non-luminous bodies by comparison with isolated spectral tints is founded upon a false conception of the nature of the light which they reflect. To determine the hue of a pigment from the analysis of the light it reflects is a problem in physiological optics the solution of which varies with the character of the observer's eye. The three primary color-curves of the eye must be determined and the total intensity of each wave-length of the spectrum of the pigment must be divided in the proportions indicated by the color-curves into three components; red, green and violet. Summing up each of these components for the entire spectrum we obtain an expression for the hue in terms of the three primary color-sensations of which it is the resultant. In default of this method, which is difficult of execution, the curves themselves are an expression of the hue, the only requisite for the interpretation of which is practice in associating the sensation of color produced by pigments with the form of curve representing them.

If we retain as the standard of purity the monochromatic tint, the intensity-curve of a perfectly pure color is a vertical line, the position of which in the spectrum indicates the hue and the length of which shows the brightness of the color. Variations from this form, in the intensity-curves of pigments, exhibit at once the kind and degree of the impurity. The intensity-curves for red-lead, chrome-yellow, chrome-green and ultramarine blue all serve to show, that purity cannot properly be measured by supposing the pigment to consist of a monochromatic tint plus a certain amount of white light, and that

[1] Lamansky, Poggendorff's Annalen cxli.

the only satisfactory method of indicating this property of pigments is by giving in some convenient unit the wave-lengths and the intensity of each wave-length of their spectra.

As regards luminosity the curves afford two kinds of information. The ordinate of each wave-length gives the brightness of that wave-length, as compared with the brightness of the corresponding wave-length in the spectrum of the standard white. The area enclosed by a curve and by the coördinates, between the origin and the points where the curve cuts the coördinates, is a measure of the total energy of the visible rays reflected by the pigment, as compared with those reflected by the standard white. These ratios stand in a definite relationship to the luminosity of the color, but they are independent of the peculiarities of individual eyes and they are in this respect a better measure of the brightness of the color.

University of Kansas, July 12, 1884.

ART. XLII.—*A Criticism of Becker's Theory of Faulting;* by ROSS E. BROWNE, M. Tech. Soc.

[Read July 11, 1884, before the Technical Society of the Pacific Coast.]*

Mr. BECKER says: "The evidence of faulting on the Comstock is manifold, etc." "Both to the east and west of the vein, too, the country rock shows a rude division into sheets, and along the partings between the plates evidences of movement are perceptible, decreasing in amount as the distance from the vein increases, according to some law not directly inferable." "Each sheet appears to have risen relatively to its eastern neighbor, and to have sunk as compared with the sheet adjoining it on the west. The consideration of a sheet or plate of rock under the influence of friction of a relatively opposite character on its two faces, therefore, forms the natural starting point for an examination of the observed conditions. It is shown in Chapter IV that if a country divided like the Comstock area into parallel sheets experiences a dislocation on one of the partings under a compressive strain equal at each parting, a vertical cross-section will show a surface line represented by two logarithmic equations."

"Where a fault of the class under discussion has occurred, and where the resulting surface has not been obscured by deep erosion, the original surface can be reconstructed or calculated, and the amount of dislocation determined."

"The theory, though worked out independently of the Com-

* See "Monographs of the U. S. Geological Survey, 1882;" vol. iii, on the Comstock Lode, etc., by George F. Becker; chapter iv, on Structural Results of Faulting.

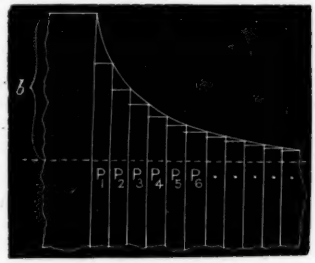
stock, applies to it with much precision. Equations can be given representing very closely the surface line of a cross-section, the amount of the fault can be determined, etc."

The above quotations from the summary, pp. 376–380, are made in order to bring before the reader, as briefly as such means will permit, some of the prominent features of the theory which it is proposed to criticise.

In the discussion under the several headings, "Transmission of energy by friction," "Distribution of energy through a system of sheets," "The velocities of moving sheet, etc.," there appears a misconception of an important question involved.

Mr. Becker says if sheet W (see fig. 1) "begins its motion with a fixed quantity of energy, and if P_1 is fixed, the entire energy will ultimately be expended in heat, sound, etc., on the contact. But if P_1 is movable a portion of the energy of W will be communicated to P_1, etc."*

1.



These statements are true, but it must be borne in mind, that in effect, the force of friction is simply a resistance to *relative* motion. If P_1 offers greater resistance to a relative movement of W than the body of sheets to the right offers to a relative movement of P_1, it follows that relative rest between W and P_1 will not be disturbed, and the latter will move with the full velocity of the former.† If P_1 is initially at rest, it will either remain at rest or acquire the full velocity of W.

"If P_1 is in contact with a third plate or sheet P_2 the energy received by P_1 will be expended wholly or in part in overcoming the resistance on the contact P_1 P_2." It should be kept in view that if P_2 moves at all, it does so with the full velocity of P_1, for the reasons above given. "If these sheets are the earlier

* The pressure exerted by W upon P_1, was considered as uniformly distributed —see * page 351.

† This statement apparently calls for some qualification, for if a considerable velocity is suddenly imparted to W, and the resistance mentioned means simply frictional resistance, the inertia of P_1 will give rise to a dislocation at contact W P_1. However, if the most reasonable conditions are imposed—if the acceleration of W is supposed to be small, and there is assumed to be a material difference between the frictional resistance which P_1 offers to motion of W and that which the body of the sheet to the right offers to motion of P_1—it is proper to consider that the resistance which the mass of P_1 offers to motion will not cause dislocation, but will result in vibrations in the elastic sheets transmitted through the projections at the contact. It is not supposed that it was Mr. Becker's intention to consider any appreciable velocity as being suddenly acquired. The "fixed quantity of energy," with which W begins its motion, cannot be energy of motion (kinetic energy).

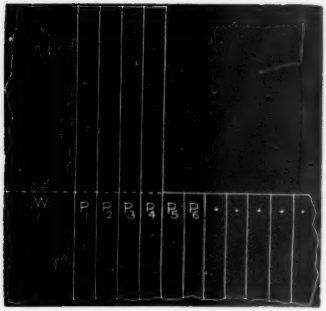
members of a series of sheets W, P_1, P_2, P_3, ... of indefinite number, then each sheet which moves will communicate a certain amount of energy to the next, and since the resistance of friction* is proportional to the distance through which it acts, each sheet which receives energy from its predecessor must move."

In other words, each such sheet must be translated. Herein lies the misconception. If the resistance, which a given sheet P_5 offers to motion, is greater than the resistance it causes to the motion of its predecessor P_4, it will remain at rest; and though it receives energy from its predecessor this energy is in the form of heat and will not cause translation of P_5.

Now follows this statement: "Since the sheets are in all respects alike and the pressure at each contact is the same, the frictional resistance or negative force at each contact will also be the same, etc."

This is an astonishing condition to impose, as it could never be realized (not even with carefully prepared sheets of paper), and to say that it could be realized approximately would but show a misunderstanding of the problem. Any small difference between the surfaces of contact, of a nature to influence friction, would change the character of the problem. There would be one contact where the frictional resistance would be less than at the other contacts and here only would there occur a dislocation. If the condition should nevertheless be entertained, there would, owing to the inertia of P_1, result a dislocation at the first contact W P_1. The sheets P_1, P_2, P_3, ... would all remain at rest, though in unstable equilibrium.

2.



In the real question at issue, then, if the contact between P_4 and P_5 offers less resistance than the other contacts, motion of W will simply produce the effect shown in fig. 2, and not the effect claimed by Mr. Becker and shown in fig. 1.

It would be purposeless to follow the mathematical developments erratically based upon this misconception of the main question involved. Suffice it to say that a logarithmic equation is reached to represent the supposed curve. However, some comment upon the "experimental verification" will not be out of place. Under this heading the author says:

* Probably "work of friction" is meant.

"If the various assumptions made are correct, a fault under certain conditions will result in a surface, a vertical section of which at right angles to the strike of the fault will present a logarithmic curve. Before proceeding to any further deductions, it is evidently desirable to test the correctness of the postulates experimentally. I have supposed the sheets of rock of infinite size as compared with their exposed margins, because on this supposition the pressure per unit of area of each parting will be the same.* If the plates were thoroughly flexible, and if the pressure were applied on a limited zone parallel to the croppings and removed by a distance greater than b from either end of the plates, then the pressure exerted on each plate would be the same, and would be distributed over an equal area, and the resulting curve would still answer to the general formula deduced.† These conditions we can approximately reproduce. If a pile of, say, one hundred slips of very thin, flexible and uniform paper, eight or ten inches long, with sharply cut edges, are laid upon a flat surface, and a narrow weight of three or four pounds is placed across them, the pressure under the weight may be considered as constant. In the experiments I have made, the weight employed was about 5,000 times as great as that of a single slip. If a blunt edge, such as that of a ruler,‡ be now applied at right angles to the longer dimension of the slips, close to the weight, with a light pressure, and be drawn away from the weight a fraction of an inch, a slight relative movement will be perceptible. If this application of energy to the system be repeated a score of times, the ends of the pile of slips would be found to form a curved surface instead of a plane. If the frictional resistance is proportional to the pressure, this curve must sensibly coincide with that given by the equation

$$y=\frac{Am^{-x}}{1+xt}\text{,"}\ \text{etc.}$$

If the above directions are followed, the pressure applied with the ruler being made sufficient, a curve will be produced; but it is significant that a blunt edged tool is used for the purpose. If "the pressure per unit of area of each parting" is to be even approximately the same throughout each parting, why not distribute the weight uniformly over the upper slip, fasten to the same, and move the weight? By proceeding in such a manner the result will be simply that illustrated in fig. 2.

* See foot note page 349.

† If it is meant that the pressure per unit of area of each parting would be the same, the first sheet should have been made absolutely rigid, and not "thoroughly flexible," in order to justify this conclusion. The present writer commits himself to the opinion that if the sheets are flexible. and the pressure applied to a limited zone, the pressure per unit of area will rapidly diminish as the normal distance from the "limited zone" increases. See page 353.

‡ The pressure under the weight might be considered as approximately constant and even as distributed approximately over the same area at each parting; but not so with the pressure under the blunt-edged ruler.

Mr. Becker's experiment in no sense, "forms a check upon the theory," since it deals with fundamentally different conditions. The fact is, the formation of this curve, in the experiment described, is due mainly to the *inequality* of the "pressure per unit of area" at the different partings.

An explanation of the formation of this curve is of little interest to the general reader; but an attempt at such will be added in order to bring out more clearly the inapplicability of the experiment to the real question at issue.

There are to be found in this Chapter IV many such headings: "Logarithmic distribution of energy," "Equation referred to the cropping as origin," "Spacing of contours," "Evidence furnished by observation," "Topography chiefly due to faulting,"* "Dynamical theory of sheets," "Rules applicable to prospecting in uneroded districts," "Application of theory to landslips." The subject matter under these headings is replete with deductions and applications, many of which might well be questioned even if the theory were correct. The present writer doubts, for instance, the existence of the conditions essential to any real significance in the application of the logarithmic curves to the Sutro Tunnel section. The fact that a carefully selected section of a natural surface may be approximately covered with portions of such curves, when calculated by the method adopted, is of little import. Doubtless many other simple curves might have proved equally serviceable. However, this question will not be discussed at present.

An Explanation of the Formation of the Curve in the Experiment with the Slips of Paper.—A B (fig. 3) represents an elastic sheet resting upon an incompressible base, and W a toothed cylinder. There is frictional resistance to relative motion at the contact between sheet and base. If a pressure normal to the surface of the sheet is applied through W, tooth 1 will compress the sheet at point P_1, as shown, and extend it in length. If now the cylinder is rolled toward B until tooth 2 comes in contact with and compresses the sheet, the part P_1 B will be further elongated. Since the pressure, and consequently the frictional resistance to motion, at point P_1 of contact between sheet and base, is great as compared with the resistance at other points of the contact, the translation caused by this elongation will be almost wholly in the part P_1 B of the sheet. If the cylinder is rolled still further until tooth 1 leaves the surface of the sheet, the part A P_2 will have contracted. After teeth 2, 3, 4, etc. have done their

3.

* Referring to the Comstock country.

work, the accumulated effect will be a material translation of the sheet in the direction of rolling.

It is easy to see that a result the same in character will be effected if there is substituted for the toothed cylinder, a cylinder without teeth, the operation being continuous.

If an edged ruler is applied and drawn from P_1 toward B the effect will depend upon the magnitude of the resistance which the sheet offers to the relative motion of the edge of the ruler. If the edge be sharp and this resistance greater than the frictional resistance between sheet and base, the result will be relative rest of sheet and edge and slipping of the sheet upon the base. If, on the other hand, the edge be blunt and this resistance less than the frictional resistance between sheet and base, the ruler will slip on the surface of the sheet carrying the depression with it, and it is easily seen that the result will be the same in character as in the case of the rolling cylinder.

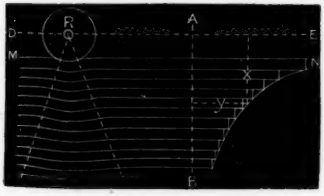
4.

In rolling the cylinder from A to B the entire sheet will be compressed to thickness t_1 (see fig. 4), and the total translation of the sheet will be approximately equal to the full amount of extension which would result from distributing uniformly from A toward B weights of sufficient magnitude to reduce the entire sheet to thickness t_1.

In explaining the formation of the curved surface the weight used by Mr. Becker will be omitted, as it only serves to keep the sheets in contact. The cylinder will be substituted for the blunt edged rubber. It will scarcely be doubted that these changes are admissible and will not affect the general character of the curve formed. They are made in order to simplify the statements.

Let fig. 5 represent an indefinite number of highly elastic and flexible sheets of paper, having their edges originally in the surface A B normal to the upper surface M N. If cylinder R* is applied with pressure to the surface M N, this pressure will be transmitted normally to the curve of depression formed. The area of surface over which this pressure is distributed will rapidly increase—hence the diminution in thickness of a sheet, due to compression, will decrease—with increase of the distance from the upper surface M N. If now the cylinder is rolled to

5.



* Let the length of the cylinder be greater than the width of the sheets, and let it be so placed that its axis is normal to the longer dimension of the sheets.

the right the amount of the translation of a sheet will decrease with increase of its distance from the upper surface M N, and thus the edges will form a curved surface.

If it is important to show approximately the character of the curve, an equation is easily deduced after making certain assumptions. Let it be assumed:

1st. That the diminution in thickness at a given point of the sheet, due to compression, is proportional to the applied normal force per unit of surface where applied.

2d. That the extension in the length of a sheet when uniformly loaded, is proportional to its diminution in thickness.

3d. That the pressure is uniformly distributed at any contact, over an area which is directly proportional to the distance x from the center of curvature of the contact surface between the cylinder and the upper sheet.

It will follow then, if c and C are constants and p represents the pressure per unit of area, that $p=\frac{c}{x}$ and since y is proportional to p, $y=\frac{C}{x}$.

The curve then will approximate in character an equilateral hyperbola, having A B and D E for asymptotes.

It is only claimed that the assumptions made are near enough to the truth to lead to a reasonably good conception of the character of the curve formed.

ART. XLIII.—*The Difference between Sea and Continental Climate with regard to Vegetation;* by Mr. BUYSMAN, of Flushing (Vlissingen), Holland.

THE difference between the vegetation of the sea and continental climates is, no doubt, best observed in the growth of the plants that are generally cultivated for different purposes in the temperate zone; as every climate has its own region or flora.

Whether the climate of a country is favorable to those plants or not is shown, in the first place, by their extension northward; and we shall first, therefore, endeavor to trace the northern limits of the most important plants, either cultivated in one country and growing wild in another, or cultivated everywhere.

To the first class most trees belong; to the second, annual or perennial plants. We begin with trees.

Pinus sylvestris L. Scotch Pine. Scotland, 59°. Norway, 70° 20′. Kola, 69°. Petschora region, 67° 15′. Obi river, 66°. Turuchansk, 65°. The Werchojansk mountains, east of the Lena river (64°), are the eastern limits of this tree.[1]

[1] Middendorff, Sibirische Reise, Bd. IV, Th. I, p. 556.

Betula odorata Bechst. (*alba* L. var.) Birch. Greenland, 61°, shrub. Iceland, 65°, shrub to 10 feet high. Britain, 59°. Norway, 70° 50′. Peninsula Kola, 69° 30′.[2] Peninsula Kanin 67°, to the Obi river 66°, and from the river Kolyma 68°, to the Peroshina Gulf 63°, and Kamtschatka; on this peninsula it is a large tree.

Quercus pedunculata Ehrh. (*Q. robur* L. var.), Common Oak. England, 58°. Norway, wild, to 62° 55′: cult. 65° 54′. Finland, coast, 61° 30′ (Björneborg). St. Petersburg, Taroslav, Perm, 58°.[3]

Larix Europæa DeC. (including *L. Sibirica* Ledeb and *L. Dahurica* Turcz), Common Larch. Norway, *Europæa* DeC. 66° 5′; *Dahurica* Turcz. 59° 55′; both cultivated. Onega river, White Sea, S. W. shore of Onega Lake, Mesen (Peninsula Kanin), 67°. Petschora river, 67° 30′. Ural mountains, 67° 15′. Kora river, 68°, northern limit in Europe. Yenisei river, 70°. Boganida river, 71° 15′. Chatanga river, 72° 30′, most northern limit of trees on the globe. Anabar, 71°. Oleneh and Lena, 72°. Yana, 71°. Yndigirha, 70° 45′. Kolyma, 69°. Anadyr, 65°. Between Ochotsk and Gishiga, 61°. Peninsula Sachalin, 49°. To Yeddo and the island Kunaschir, 43° 45′. On the shores of Kamtschatka the larch is nowhere to be found; in the valleys of this peninsula, however, protected from sea-winds, it is a very large tree.[4]

Pyrus Malus L., Apple. Shetland Isles, cult. Britain, 57°. Norway, cult., 65° 28′; wild, 63° 40′. Gulf of Bothnia, 63° 45′, cult. Finland, 63°, cult.; 60° wild. Northern shore of Onega Lake, cult. Narva, 59° 30′, wild. Twer, 56° 45′, wild. Nishny Novgorod, 56°, wild. Kasan, 56°, wild. Southwest of Orenburg, 50°. Kopal, Asia, 45°.

Fagus sylvatica L., Common Beech. Britain, 58°. Norway 59°, cult. 67° 56′. Sweden, 57°. Königsberg. Poland. S. W. Russia. Krim. Caucasus. Persia.

Castanea vesca Gærtn., Chestnut. South Britain. Germany (to the island of Rüyen). Austria. Caucasus.

Populus alba L., Abele Tree. Britain, 56°, wild and cult. Norway, cult., 67° 56′. Germany, wild and cult. Austria. Russia: Volhynia. Kiew. Charhow. Tambow. Kasan. Ufa. Altai Mountains.

Populus tremula L., Aspen. Britain, 59°. Norway, 70° 37′. Russia. Peninsula Kola, 69° 30′. Eastern shores of the White Sea, 66°. Yenisei, 66°. Kolyma river, 67° 30′.[5] Amur river.

Alnus incana W., Hoary-leaved Alder. Canada. Norway,

[2] Ibid., p. 567.
[3] Ibid., p. 575.
[4] Middendorff, Sibirische Reise, Bd. IV, Th. I, p. 536.
[5] Middendorff, p. 573.

70° 30′. Kola, 69° 30′. Yenisei, 67°. Amur region. Petropaulovsk, on Kamtschatka.

Ulmus campestris L., Common Elm. Britain, 57°. Norway, cult., 63° 26′. Russia: Ilmen Lake. South of Moscow. Riazan. South of Kasan and Ufa to the Ural mountains.

Tilia Europæa L. (inclusive of *parvifolia*, *grandiflora* and *intermedia*), Lime Tree. Britain, 57° (*parvifolia*). Norway, wild, 62° 9′; cult., 67° 56′. Petersburg. Kargopol. Ust Süssolsk, about 62°. Solikamsk. Ural mountains, about 58° 50′. Werchoturje.

Vinis vinifera L., Common Grape. Bretagne, 47° 30′. Liège, 50° 45′. Thuringia to Silesia, 51° 55′. South Galicia. South Russia, between about 48° and 49°. Astrachan. Buchara in Turkestan, 40°; here the vine is cultivated in the open fields.[6] Chiwa, 42°. China, 40°. California.

This plant cannot stand the extreme cold of the Asiatic continental winter climate, and requires a very warm or a very long summer (California); it cannot, therefore, be cultivated generally in Britain. The fact of its being cultivated with success in California is no doubt owing to the continual clear sky and then to the *direct solar warmth*; the *mean temperature* is here in summer *much lower* than in Europe in the same latitude.

Triticum vulgare Vill, var. *æstivum*, Summer Wheat. Britain. Norway, in the fields, 64° 40′; in gardens, 69° 28′. Finland, 65°.[7] Dwina river, 63°. Yakutsk. Western shores of North America, 55°. Fort Liard, 60° 5′ (N. W. territory of Canada).[8] Peace river, 56° 6′. Ontario. East Canada.

Hordeum vulgare L. (including *hexastichon*), Barley. Faröe Isles, 62° 15′, seldom ripe grains. Norway, 70°. Western shores of the White Sea, 67°. Ob river, 61°. Yakutsk, 62°. Udskvi Ostrog, near the Ochotsk Sea, 54° 30′. Kamtschatka (inland), 53° to 54°. N. W. American shore south of Sitka, 57°. Fort Norman, Mackenzie river, 65°.[9] East of Winnipeg, 50°. St. Lawrence Bay, 50°.

Avena sativa L., Oat. Scotland. Norway, 69° 28′. Finland, 69°. Asia: the same latitude as *Hordeum vulgare*. Yenisei, 61°. Yakutsk, 62°. Kamtschatka (inland). North America: the same latitude as *Hordeum vulgare*.

Secale cereale L., Common Rye. Britain. Norway, 69° 30′. Finland, 67°. Mesen river, 65° 45′. Petschora region, 65° 45′. Ural mountains, 57°. Obi river, 60°. Yenisei, 59° 30′. Yakutsk, 62°. Kamtschatka (inland). N. America, a little south of the latitude of the barley; eastern shores, 50°.

[6] Grisebach die Vegetation der Erde, vol. i, p. 407.
[7] Middendorff, p. 709.
[8] Richardson, Searching Expedition through Rupert's Land, vol. ii, p. 267. Fort Liard is between 400 and 500 feet above the sea-level.
[9] Richardson, p. 269.

Solanum tuberosum L., Potato. Britain. Norway, 71° 7′. Russia, Pinega river, 65°. Turuchansk, 65°. Yakutsk. Shores of the Ochostk Sea. Kamtschatka. Kadjak Island. Sitka Island. Mackenzie river, 65°. Canada. Labrador, 58° 45′.[10] Greenland.

Zea Mays L., Indian Corn.—This plant requires also a very warm summer to ripen. In England it can be cultivated only as a green vegetable; on the western shores of Europe the cultivation is profitable only to the 46th degree N. L., while in the valley of the Rhine it reaches to 49°. In Northern Germany the grain usually does not ripen. In North America, however, it is cultivated with profitable returns up to 51° N. L.[11] The period of vegetation varies there between seven and three months. Cultivation of the varieties maturing in a shorter period has been tried in Europe but without success; they were transformed after a few generations into the common corn. There must exist peculiar relations between the American climate and the vegetation of this plant.

Thus we see that of the plants just named, the Larch, the Pine, the Birch and the Aspen go into Siberia, with its excessive continental climate, farthest to the north; yet many of the cultivated plants mentioned above, and almost all those of the temperate zone, are either cultivated or grow wild in the sea climate of Norway to very high latitudes.

On the northwest shores of America the Pine attains considerable size (Sitka) in a climate with continual precipitation, but the same size is to some extent observed on the Rocky Mountains (eastern slope), where the climate is wholly different.

In British Columbia the climate is continental and very cold in winter, yet the same gigantic trees are here to be found as on the coast; precipitation takes place in spring, but the amount is very great.

In California, with the largest coniferous trees of the world, (*Wellingtonia gigantea*), rain falls chiefly in winter (November to April); the other months are dry. The cause is known: the polar stream coming from the northwest reaches the Californian coast under about 45° N..; the water being in summer much colder than the land and the winds in this season mostly northwest, no precipitation can take place. This is the cause also of there being very little difference in temperature between summer and winter;[12] but climatical causes will not alone explain the gigantic vegetation of the west and northwest shores of North America. In Norway or Ireland, both having very wet

[10] Petermann, Geogr. Mittheilungen, 1859, p. 124.
[11] Richardson, vol. ii, p. 267.
[12] San Francisco, winter 46°, summer 53°, year 51°.

climates, such enormous trees are nowhere to be found. It is a peculiarity of the Pacific coast vegetation, the cause of which is unknown.

In the southern parts of the Amur region in Asia, there is in summer a luxuriant vegetation; the annual precipitation amounts to 27·56 inches (about the same amount as in Germany), and the plants much resemble those of Central Europe,[13] and this notwithstanding a winter temperature much lower than is observed in the most northern parts of Lapland; but the summer is here much warmer than in Europe under the same latitude, and *precipitation takes place only in summer.*

In the interior of Siberia the vegetation consists chiefly of coniferous trees; thus the luxurious growth in the region just named must be caused by the influence of the sea climate, as Middendorf suggests,[14] though there is a mountain chain on the east coast.

The extensive forests of Russia and Siberia prove that an extreme continental climate is resisted by some coniferous and other trees; but it is evident that in general a sea climate with mild winters, and thus a long period of vegetation, suits them best.[15]

As we have seen, the northern limit of the cultivation of corn reaches to a much higher latitude over the continent than near the seashore. On the northwest coast of North America the Island of Sitka (57° N. L.) and Radjah are on the extreme limit. On the Faroe Islands barley is cultivated, but corn seldom ripens;[16] the cause is absence of sunlight on account of the continual cloudy sky, storms and precipitation causing low temperature in summer (mean temperature at Thorshaven in July, 55°); for corn wants a sunny climate and the direct influence of the sun's rays. This explains why it can be cultivated within the polar circle (Norway) where the sun in the summer season remains constantly above the horizon.

In North America, on the shores of Hudson's Bay, the tree limit goes down to 59°, the corn limit to 50° (Ontario). On the shores of the Ochotsk Sea corn cannot be cultivated at all, even on the south coast under 50°. In Greenland also the cultivation of corn is impossible. The causes are the same as stated above—the sea winds, wet climate and fog in summer; that is, want of sunlight.

Of all cultivated vegetables *Raphanus sativus* L. et var. (Radish), *Brassica Rapa* L. et var. (Turnip) and *Brassica Napus*

[13] Kittlitz. Vierundzwanzig Vegetationsansichten von Küstenländern und Inseln des Stillen Ozeans, p. 53.

[14] Middendorff, p. 763.

[15] The stems of all the Siberian trees are slender compared with those of Europe, even when they are centuries old. Middendorff, p. 632.

[16] Martins, Sur la vegetation de l'Archinel des Féroé.

L. et var. (Rape) grow as far north as there are settlements. In Norway beyond 70° N. L.; in Siberia to the Polar Circle; on the N.W. coast of America to 64° 45′ (Nulato) and Redout St. Michael (63° 30′); in the interior to 67° (Fort Good Hope).[17] In Greenland, Rapes, Turnips, Cabbage and Salad are cultivated under 70° L. (Island Disko).

The potato follows the above named plants in their distribution to the north and belongs also to sea climate species. On its northern limit, however, in Siberia as well as in N. America, it reaches only the size of a walnut.[18] In Greenland, only the most careful treatment can produce eatable potatoes. The plant never blossoms there.[19]

Comparing the vegetation of the extreme continental climate with that of the extreme sea-climate on the globe, the continental has the advantage. The South Shetland Islands under 60° –63° S., are the most southern limit of phanerogamous plants (only a grass—*Aira antarctica* Forst—is found there); and on Cockburn Island, 64° S., the last trace of vegetation is found (cryptogamous plants). In this latitude north there is in Siberia a forest of very high coniferous trees. In the antarctic regions there are several causes why vegetation ceases at so low a latitude, but these are all consequences of the chief cause, viz: the fact that the whole southern hemisphere, with the exception of relatively small spaces, is covered with water; a continual very low barometer and severe storms,[20] combined with a very low summer temperature,[21] banish all vegetation.

The extreme continental climate has also its disadvantages, but chiefly with relation to the cultivation of corn. In the first place, corn is very often destroyed by night frosts, which make the harvest uncertain.

The constantly frozen ground is the chief cause why corn cannot be cultivated in Siberia beyond 62° (Yakutsk). The temperature of the soil in which the roots vegetate varies between 36° and 41°. Thus, notwithstanding the mean temperature of June at Yakutsk is 55°, and that of July 62°,[22] the vegetation is relatively slow,[23] though its period (10 to 12 weeks) is the same as observed in Central Europe. The same period is observed in North America, under 63° (Fort Simpson)[24] of the barley. (Wheat does not come to maturity there.) But

[17] Richardson, vol. i, p. 214.

[18] Middendorff, p. 700.

[19] Etzel, Grönland geogr. und statistisch beschrieben, Stuttgart, 1860, p. 282.

[20] Lowest reading of the barometer by the United States Exploring Expedition under Wilkes on lat. 65° 15′, 27·50. See Narrative of the Expedition, London, 1852, vol. ii, p. 281.

[21] Under lat. 64° 5′ mean temp. of January, 1843, 31°; under 62°–66°, in February, 31°. See Ross, Voyage in the Southern and Antarctic Regions, vol. ii, p. 352–360.

[22] Middendorff, p. 772.

[23] Middendorff, p. 718.

[24] Richardson, vol. i, p. 165.

a harvest of thirty to forty times the quantity that was sown alternates in this climate with years of no harvest at all.[25]

As is well known, the native plants withstand the lowest temperatures of the Siberian winter.

Returning to Europe we have seen that even the climate of the northern parts of the British Isles is not suited for many vegetables and other cultivated plants.

It is Germany which has a climate adapted to almost all the plants of the temperate zone and to those commonly cultivated. We see the vine in this country ascend farthest to the north, while corn and all vegetables ripen their seeds perfectly. The climate is clearly that best suited for the vegetation of this latitude.

Now, if we compare the mean temperature of July in Germany with the mean for the latitude (for 50° N.—62°) calculated by Dove, we find that even in this country the summer temperature is, in general, *only a few degrees above the calculated.* Germany is crossed in July by the isotherm of 68°, and Britain by that of 59°; but the difference in vegetation is not caused by a difference in mean temperature of nine degrees, but by the difference in the *days of sunshine.*

Thus we come to the conclusion that a mixed climate with relatively mild winters (the anomaly of temperature for January is for Germany about +9° on the 50th degree of latitude) and *warm sunny* summers is the condition best suited for the vegetation of the temperate zone.

Flushing, June, 1884.

ART. XLIV.—*Chemical Affinity;* by JOHN W. LANGLEY, Ann Arbor, Michigan.

[Address before Section "C" of the American Association for the Advancement of Science, Philadelphia, 1884.]

IN reviewing the history of each living being and of every intellectual conception we are at once made aware of a law of growth, the most general and fundamental possible, namely, that of development, or progression along what often seems to be a predetermined line whose constraining influence is so powerful that it is only by following it that the organism can escape destruction.

Development, while it may be continuous, both for the individual and for the race when broadly looked at over large intervals of time, is, on the other hand, a process which in its details is constantly interrupted both by alterations of directions and by arrests of action which may even go so far as to cause retrograde metamorphoses.

[25] Middendorff, p. 720.

A plant may readily grow unsymmetrically if shaded on one side; but that error of form will be largely corrected when it is again bathed with light which comes from all directions. This partial arrest may even arise from the plant itself, as when the excessive growth of the vine in forming new wood saps the energy which should go to the formation of fruit, and the grapes, which alone make the plant valuable to man, never reach that fullness and flavor which should recompense the toil of the husbandman.

All of us here are constituent intellectual atoms in a great ideal organism called Chemistry. We know the long and honorable history of our science, we know too its wonderful progress in the past fifty years; we perceive how from the single stem of alchemy it has thrown out branches in all directions, Mineral, Organic, Analytical, Synthetic, Agricultural, Physiological, Biological Chemistries; but has it furnished a corresponding number of great far-reaching laws? Has it been equally prolific of grand hypotheses which have stood the test of time?

Will you pardon me if I venture to apply the analogy of the plant, and to ask whether our development has been symmetrical, whether some struggling bud put forth in our youth has not been starved and shaded by the abundant leafage of our branches, and whether in the rapid accumulation of facts from that great diffused solution of them called Nature, while we may have greatly increased our quantities of chlorophyl and cellulose we may have been equally successful in elaborating well-rounded generalizations which fill the intellectual taste with a sense of delight, and which stand forth as the declared fruit of our toil.

Such a fruit bud our science put forth in its alchemical stage under the name of affinity. During the early part of the present century the idea received considerable expansion and showed at one time a vitality comparable with the condition of the doctrine of the conservation of energy prior to the year 1850.

Having reached this stage the development of a theory of affinity seems to have been arrested and soon it is seen occupying a position of constantly decreasing interest to chemists. The proof of this statement is easily found by comparing such works as Daniel's Introduction to Chemical Philosophy, Thompson's History of Chemistry and Daubeny's Atomic Theory, published in 1830 and '31, or the works of Berzelius, with any recent manual of inorganic chemistry. In the older books the amount of space given to the treatment of chemical affinity is relatively large, while in the treatises of to-day it is in many cases hardly even mentioned.

In the article Chemistry, in the new Encyclopædia Britannica, covering 120 pages, there is not a single paragraph referred

to the title of affinity, and less than half a page devoted to it indirectly. In Watt's Dictionary of Chemistry, including the supplements, out of a total of 9,665 pages only 62 are devoted to affinity where it appears under the head of Chemical Action. In Wurtz's Dictionnaire de Chimie the treatment of affinity under the several heads of Chaleur, Electro Chimie, Affinité, Atomicité, etc., is relatively fuller, but still the proportion is quite small; and in that excellent manual, Remsen's Theoretical Chemistry, the second edition of which was published last year, the word affinity does not even occur in the index. The causes of this almost complete abandonment of a word and an hypothesis at one time considered of fundamental importance can best be traced by reviewing briefly the history of that part of speculative chemistry which is related to the doctrine in question, and it will become apparent that it is the word only which is becoming obsolete. I will therefore venture to ask your attention to what I am only too well aware is but a sketch of the development of theories concerning the nature and fundamental cause, or causes, of chemical phenomena.

I. The Conception of Affinity.

The earliest appearance of the idea, which has since been named chemical affinity, is found in the writings of Hippocrates in the fifth century B. C., where the opinion is expressed that when two bodies unite to form a compound, a certain common principle must indwell in them, for it is laid down as a fundamental postulate that "Like unites only with like," hence the two bodies must possess some common principle, or have a bond of kinship between them.[1] This conception prevailed with more or less clearness for several centuries, but it is not till the year 1698 that we find the word *Affinitas* employed and defined. It first occurs in the writings of the alchemist Barchusen,[2] and the conceptions of Hippocrates were still the ruling ones. Thus Barchusen explains the impossibility of completely isolating the four elements by saying that they have for each other a strong affinity which causes one to mingle with another, and which cause is derived from a principle common to them all.

Boerhaave, the celebrated physician of Leyden, in his elements of chemistry which appeared about 1732, was the first to extend the meaning of the term *Affinitas* or *Verwandtschaft*, since he says, "the effort also of like substances to unite is due to the working of the same force;"[3] and elsewhere, in explaining the cause of solution, he says, "In this last case" (that of the action of aqua regia on gold) "why do not the particles of gold which are nineteen times heavier than the particles of aqua regia collect together in the bottom of the vessel. Do you not see clearly that there is between each particle of gold

and each particle of aqua regia a force in virtue of which they seek each other out, unite and retain each other."[4] We also notice in Boerhaave's writings a tendency to regard combination as due to the attraction of opposite, rather than to the union of similar qualities; for he compares the action of an acid upon iron to a marriage, and says that the combination comes rather from love than hate.

Two of Boerhaave's successors, St. F. Geoffroy and Torbern Bergmann, appear to be the authors of a new conception which was subsequently known under the name of Elective Affinity. Geoffroy attempts to indicate the order of chemical actions, or as we should now call it, the relative intensity of combining power, by arranging several bases in the order in which they displace each other. Thus one of his tables was the following:

Vitriolic Acid.[5]

Sel Alkali, fixed.	Earths.	Copper.
Sel Alkali, volatile.	Iron.	Silver.

It was soon discovered, however, that an order of bases which might be correct for one acid would be incorrect for another, and that a given substance would take different positions in the two.

The following, which is a portion of one of Bergmann's lists published in 1783, will show the fact:[6]

Gaseous Acid. (*Carbonic.*)	Acid of Sugar. (*Oxalic.*)
Pure heavy earth.	Lime.
Pure lime.	Heavy earth.
Fixed vegetable alkali.	Magnesia.
Fixed mineral alkali.	Fixed vegetable alkali.
Magnesia, etc.	Fixed mineral alkali, etc.

The reversal of the order of attractions was explained by assuming the existence of preferences or special attractions between acids and certain bases, and was known under the name Elective Affinity, a term which has remained in chemical literature till quite recent times, and indeed, was very generally used within the recollection of most of us here present.

The chemist, Glauber, 1689, was one of the first to recognize this fact of differential attractions. He teaches[7] that "potash, lime and zinc oxide, with application of heat, drive out ammonia from sal-ammoniac because the zinc, as also potash and lime, is of such a nature that it has a great community of interest with all acids, loves them and is also loved by them; accordingly when warmed the acid of the salt (muriatic) attaches itself to it, combines with it so that the sal volatile is set free and is distilled to a subtle spirit."

The next advance in the direction of precision was made by Wenzel,[8] who, in a work entitled *Lehre von den Verwandschaften*,

published in Dresden in 1777, showed that when two neutral salts act upon each other by double decomposition, the new salts formed are also neutral and thus prove chemical unions to be governed by some general law which determines how much of one acid must be taken to displace another. Although Wenzel's work attracted but little attention at the time, we can now see on looking back that it marked a very important discovery, for he must be regarded as the first man who apprehended with any distinctness that fundamental law of chemistry, definiteness of action, which was subsequently enunciated and is familiar to us to-day under the name of the "law of definite proportions." The final result of Wenzel's discovery was the establishment of the law of equivalent proportions through the labors of Richter, Thompson, Wollaston, Berzelius and others, and from equivalent proportions sprang the Daltonian hypothesis of atoms which has developed into the all but universally accepted Atomic Theory of the present day.

The atomic theory, however, is not necessarily coterminous with hypotheses about affinity, and indeed in many respects it is independent of them; the development of its history is therefore foreign to the purposes of this paper, but if we turn back to the period which immediately follows Wenzel's discovery, which was that of the re-birth of the atomistic theory of the Greeks under Dalton's parentage, we see that it emerged from opposing views about the nature of affinity, and at this point, therefore, the two speculations have a common history. The opening of the present century witnessed an active controversy between the advocates of the new, or equivalent and atomistic school, against the partisans of the older philosophy. Prominent among the latter stands Berthollet who was a consistent and earnest opponent of the new doctrines. In his well known work, *Essai de Statique Chimique*, published in 1803, he maintains the proposition that all unions are caused by the joint action of two forces which are opposed to each other—cohesion and elasticity. He denies entirely that the union by equivalent or definite proportions is a fact. In opposition he brings forth his celebrated theory of mass, according to which combination occurs under the influence of cohesion and in proportion to the masses of the reacting bodies, being directly proportional to these two forces and inversely proportional to the elasticity or volatility. Berthollet considers that there is no distinction of kind between chemical union and mixture except that in the first the action of cohesion is more apparent. He says,[9] "The force of cohesion is often a cause which determines combinations. Whenever there is produced some solid substance, whether by a separation or by a combination, we must look to the reciprocal action (cohesion) of the parts which

acquire solidity for the cause which produces it, although it did not manifest itself previously. Alkalinity and acidity have no influence on the reciprocal action of salts which are in the neutral state, but all the phenomena which they produce must depend on the properties which emanate from the reciprocal action of their integral parts. In the mixture of liquid substances (neutral) those combinations which ought to act with a force of cohesion capable of separating them ought to be formed and separated in fact."

The position assumed by Berthollet was, of course, finally overthrown by the improvements in methods of analysis on the one hand, and by the Daltonian theory of atoms on the other; but it is a noteworthy fact that it is only as a complete and universal explanation of chemical action that Berthollet's theory fails. In many respects his position still holds good and his views on the influence of mass are being now revived and partially confirmed by researches made within the present decade.

The progress made in the allied science of physics now begins to react on chemical studies and we find the subject of electricity, which was opened by Galvani and Volta, taken up and pursued by men who are eminent both as electricians and as chemists. Davy, in 1807, and later more fully in 1826,[10] introduced the electrical theory of the nature of chemical affinity and stated that "chemical and electrical attractions depend upon the same cause, acting in one case on particles, in the other on masses of matter." His contemporaries and successors, Oerstedt, Grotthus, Ampère, Becquerel, Berzelius and Faraday amplified and extended the electrochemical theory. Grotthus contributed his well-known hypothesis of liquid polarization. Ampère considered that each atom is surrounded by a special atmosphere of electricity, positive or negative, and that combination of atoms occurs by the neutralization of the opposing atmospheres. Berzelius held that the atoms have poles. He says,[11] "Affinity is only the effect of the electric polarity of the particles; electricity is the primary cause of their chemical action; it is the source of the light and heat disengaged during combination;" and finally Faraday's immense contribution to electro-chemistry is too well known to need any further mention here.

Notwithstanding this array of great names and the stores of experimental knowledge contributed by their owners, electrical hypotheses do not seem to have added much that is valuable to the theory of chemical action except in one respect, which, however, is a fact of the utmost importance, namely, that whenever combination or decomposition takes place the corresponding decrease or increase in the value of the affinity involved is revealed as a definite and measurable amount of energy, which

may be either electrical, thermal or mechanical. We have by this theorem a mode of measuring affinity quantitatively; but electrical theories do not establish the *nature* of this force beyond dispute, and this is shown by the fact that the English school of electricians, under the leadership of Sir William Thomson, have for some years been divided in opinion as to the sources of the current developed by the galvanic battery, between the old contact theory of Volta and the chemical theories of Davy and Faraday. While the electro-chemical theory was being developed the founders of the atomic theory were not idle, and in that wonderfully fruitful decade which witnessed the enunciation of Dalton's views we find also the nucleus of an idea which has an important bearing on the nature of affinity.

In 1811 Avogadro[12] formulated that law which is now regarded as the strongest bolt in the framework of the atomic theory; but in stating his conclusions in regard to the number of "elementary molecules" in equal volumes of gases he necessarily introduced the conception of what is now the fundamental distinction between atoms and molecules, and its later development into our belief in the two orders of combination, atomic and molecular.

This theorem, of the utmost importance to the atomists, cannot, however, be considered as a material contribution to the theory of affinity, because the actions of this force are experimentally evident and are, therefore, not dependent for their verification on the molecular theory; but the form which this idea subsequently took in the mind of Brodie was, on the contrary, of the highest importance for it is essentially a new conception.

In his paper entitled, "On the state of the elements at the moment of chemical change,"[13] this chemist regards the molecules of elementary bodies as composed of atoms. The difference between the action of an element when free and when combined is due chiefly to the fact that when free the element is combined with itself in the form of an integral molecule. He says, "The general object of the paper may be considered as to prove that, at the moment of chemical change, the same chemical relation exists between the particles of which certain elements consist, as between the particles of compound substances under similar circumstances, on which relation the phenomena of combination and decomposition depend; that, in short (to use common language), the particles of the element have a chemical affinity for each other." It is true that Brodie's terminology is drawn both from the atomic and from the electro-chemical theories, for he uses the expression, "Polar relation" instead of chemical affinity, but his idea

is actually independent of these hypotheses; for what he really shows is that an element may combine with itself. What is new and original in his conception is that affinity can be exerted by one portion of an element on another portion of the same element, and hence there is no distinction of kind between the attraction of a body for other substances and its attraction for itself. This must certainly be regarded as an important extension of former ideas about combination. How fertile it is we see in its application to the structural formulæ of the organic chemistry of to-day.

There remain three discoveries which have brought modifications into the older conception of affinity. They are: 1st, The influence of structure or position; 2d, The subject of valence; 3d, The periodic law applied to the elements. Two of the discoveries are, compared with the long history of the science behind them, almost affairs of yesterday. All of them are now subjects of debate and controversy, and they have taken their present form rather from the nearly simultaneous labors of many chemists than from the projecting force of a single brain.

To trace the history of these doctrines would be difficult; to apportion justly the share of merit belonging to each contributor would be impossible, for we are now in the midst of the struggle, conflict and change which mark the progress of every living idea, in the same way that they are necessary accompaniments of every vital organism. It is too soon, therefore, for any one to know what part is destined to remain and what to perish.

The germs of the idea, that the position of an element in a compound influenced profoundly the ordinary behavior of that element, originated on the one hand in the theory of radicals which owes its origin to De Morveau, 1787, Berzelius, 1817, and especially Liebig, 1832; and on the other, in Dumas's discovery in 1834 that chlorine could be substituted for hydrogen. Although the term radical as now used means something quite different from Liebig's radical, it is certain that our present conception of acids, as bodies which can be divided into hydrogen and an acid radical, is justified only from the discoveries of those chemists. It is unquestionably true that in acetic acid $HC_2H_3O_2$ we have hydrogen in two distinct positions, or, if I may be allowed the expression, two kinds of hydrogen: one, the basic, replaceable by a metal; the other, that within the acid radical, not displaceable by a metal, but easily removable by chlorine; and further, the substituted chlorine will have lost its familiar characteristics; for example, it will no longer precipitate silver, but will, on the contrary, assume a part of the duty previously borne by the hydrogen in the new

acid, chloracetic, thus formed. Evidently we have here shown to us a new property of elements brought out by the facts of substitution, and shown with equal distinctness by the facts of isomerism. It does not arise from the particular symbol selected, or from the expressions atom and molecule. If the atomic theory were abandoned to-morrow the above indicated experimental differentiation of hydrogen into two states or kinds would receive our rational indorsement though all our vast wealth of atomic expression had perished.

The invention of the terms valence, or "atomicity," is generally credited to Adolph Wurtz, but the idea behind the names grew up so gradually from the theory of types, from the study of radicals, and from the controversy on the cause of etherification, also from the labors of Laurent, Gerhardt and Sterry Hunt, that it is hardly prudent to assign any specified year as the exact date of its origin. The "periodic law" is customarily associated with the name of Mendelejeff,[14] and modifications in the form of the law with that of Lothar Meyer.[15]

There is also an English chemist, J. Newlands,[16] who claims to be the originator of the discovery; his speculations being published in 1864 while Mendelejeff's did not appear till 1869. Both of these conceptions, valence and periodic law, are immediate outgrowths of the atomic theory. The values assigned under them, and even their very form, depend absolutely on our choice of the numbers expressing atomic weight; for instance, the distinction between monad chlorine and dyad oxygen wholly disappears when the old symbols, HO for water, and HCl for hydrochloric acid, are employed. It is an open question whether valence has any proper connection with affinity. Many chemists make an absolute distinction between them; moreover the doctrine of atomicity is so preëminently a living issue of to-day that any discussion of it here would be out of place.

Finally, I will close this review with a condensed statement of the principal theories of affinity, taken from Watts' Dictionary:[17]

1.—"*Chemical combinations are produced by universal attractions.*"

The most noted adherents of this view are, Newton, who considered affinity as identical with the force of gravitation, and Berthollet, who held it to be the same as cohesion.

2.—"*Chemical combinations are produced by a peculiar power called affinity, distinct from universal attraction.*"

Under this head we may place the alchemists and the believers in elective affinity.

3.—"*The union of heterogeneous atoms is the result of electrical attractions.*"

This includes Davy, Ampère, Berzelius and perhaps Faraday.

4.—"*Chemical action results from a constant motion among the ultimate particles of bodies, this same movement likewise giving rise to the phenomena of heat, light, and electricity.*"

This is Williamson's theory of incessant atomic interchange between all molecules in solution.[18] The same hypothesis has also been sustained by Kekulé and Michaelis.

The above closes this very imperfect sketch of the growth of the *conception* of affinity, but it ignores the important dynamic problem connected with it. Let us turn our attention to the questions of force and energy which form so important a part in the history of every chemical change.

II. Quantitative Measurements of Affinity.

The earliest attempts to measure the strength of affinity appear to be those of Geoffrey and Bergmann by arranging the several bases in the order in which they combined with a given acid, or as we should now say, in the order in which they replaced each other. Illustrations of these tables have already been given and it was apparent at a glance that the elective affinity so measured could at best be only related to some one reaction arbitrarily chosen, and that the strength of attraction, as shown by the order in which the bases were arranged, was variable and depended on the nature of the acid selected.

These tables were amplified and improved by Young and Richter, the latter of whom, in his work published in 1792,[19] gave numerical values for what he calls the capacities of saturation which belong to the several acids and bases. These numbers however do not express the strength of chemical action in terms of force, but rather the weights of the several bases which combine with an acid; they are therefore primitive determinations of equivalent weights, and hence they belong more to the history of the atomic theory than to that of affinity.

In referring to the law of Avogadro I said that while he introduced the distinction between the two kinds of "elementary particles" from which has since come our existing belief in the two kinds of union, atomic and molecular, still his proposition could not be considered an important contribution to the theory of affinity while it rests for its validity on the language of the atomic theory. The proof of this conclusion will be evident when we consider that the same discrimination between the two kinds of chemical union was very clearly fore-

shadowed from speculations concerning the value of chemical attractions before Dalton's hypothesis was given to the world.

An English chemist, William Higgins, Professor of Chemistry to the Dublin Society, published in 1789[20] a work in which the composition of several bodies is attributed to the union of "ultimate particles," sulphurous acid being formed of one particle of sulphur and one of oxygen, "Nitrous air" of two particles of dephlogisticated air and one of phlogisticated air, etc. He assumes that the attractions between iron and phlogisticated air (oxygen) may be expressed by a certain number, seven, for example; that the force between sulphur and phlogisticated air will then be represented by six and seven-eighths; finally that the iron will also attract the sulphur and the oxygen not already combined with itself by the feebler force of two. Now under these conditions the iron cannot break up the sulphur compound nor the sulphur the iron compound, but both the phlogisticated iron and sulphur will be united into a compound system by this residual force of two existing between the groups. This is exactly what would be represented by the equivalent symbol for ferrous sulphate, FeO, SO_3, where the oxide of iron FeO, and the sulphuric acid SO_3, were each regarded as entire or binary compounds united to form the ternary body, FeO, SO_3.

Shortly after these attempts of Higgins, we find, in the opening years of the present century, three general methods indicated for the study of the force of affinity. Instead of being successively taken up and abandoned, like all preceding speculations, they have remained steadily in use during the eighty years which have intervened, and they are to-day still the most promising means at our disposal. These three methods may be called the thermal, the electrical and the method of time or speed. It will be convenient to consider each one separately.

The thermal method was first indicated by Lavoisier in a memoir, a portion of which will bear quotation. He says:[21] "The equilibrium between the heat which tends to separate the molecules, and their reciprocal affinities which tend to reunite them, can furnish a very precise means of comparing affinities with each other; if we mix, for example, at any temperature below zero (Centigrade) an acid with ice, it (the acid) will melt it until it is so enfeebled that its attractive force on the molecules of the ice becomes equal to the force which makes these molecules adhere to each other, and which is so much the greater as the cold is more considerable; thus the degree of concentration at which the acid will cease to dissolve the ice will be so much the greater as the temperature of the mixture is lowered below zero, and we can refer to the degrees of the thermometer the affinities of acids for water according to various degrees of concentration."

This method, indicated by Lavoisier, would seem to be a promising one but it has never been followed, so far as I know, by anybody unless it may be by Guthrie in his investigation of Cryohydrates.[22]

The study of the heat evolved when various elements unite with each other and when acids combine with bases has been pursued by many observers. The literature of the subject is already large and it now constitutes a very important branch of our science under the title of Thermo-chemistry. Early pioneers in this field were, Thomas Andrews 1844,[23] Thomas Woods 1851,[24] Favre and Silberman 1853,[25] J. Thomsen 1853,[26] M. Berthelot 1864 and Alex. Naumann.[27]

The work of Thomsen, entitled "Thermochemische Untersuchungen," in three volumes, published at Leipsic, in 1882, and that of Berthelot, "Essai de Mechanique Chemique," in two volumes, Paris, 1879, are models of painstaking and exhaustive research. By the labors, chiefly of these two men, we now know the thermal values corresponding to many thousands of chemical reactions. We have learned that the energies of a reaction which can be brought about in two methods, either in the dry way or by solution, differ in the two cases; that salts in solution are in a partial state of decomposition; that the attraction of a polybasic acid radical is not the same for the successive portions of base added, and that the behavior of a monobasic acid in solution differs essentially from that of a dibasic or tribasic acid.

The most important generalization to be drawn from thermochemical phenomena is that the work of chemical combination, or the total energy involved in any reaction is very largely influenced by the surrounding conditions of temperature, pressure and volume; and the conclusion they force upon us in regard to the nature of affinity is most important, namely, that this force in accomplishing work is dependent, like all other forces, on the conditions exterior to the reacting system which limit the possible amount of change. Affinity is therefore at last definitely removed from the category of those mystical agents so often invoked by our predecessors in a less critical age as belonging to causes which had no correlation with the general forces of nature.

Under the title *Dissociation*, St. Claire Deville gave to the chemical world in 1857[28] a new and fruitful method of investigating the nature of compounds. By determining the temperature at which bodies break up or are dissociated he was able to perform a purely analytical operation on them not complicated by the introduction of any extraneous form of matter, and since the gradual increase of temperature can be closely adjusted and watched, we have in the process of dissociation the perfection of an almost ideal analysis.

The laws developed by Deville and his successors in this field show us, that after the point is reached at which decomposition commences, the further breaking up is determined by the pressure of the evolved products of the reaction, so that the permanence of the body depends on the magnitude of two variables, pressure and temperature, either of which may be varied at will through a wide range. Deville thus gives us a fundamentally new mental tool with which to attack the problem of affinity by showing the close parallelism between chemical decomposition and the ordinary evaporation of a liquid at its point of maximum tension.

The electrical method of dissecting chemical forces has been followed less actively than the thermal one. Besides the well-known experimental contributions of Davy, Becquerel and Faraday, many other more recent workers have studied the chemical changes of the battery and the electrolytic cell. Among these may be mentioned Joule's researches on the heat absorbed during electrolysis, and especially the work of C. R. Adler Wright on the "Determination of Affinity as Electromotive force" in the Philosophical Magazine for 1880, 1881 and 1882.

The general outcome of these researches is that the products of electrolysis are so numerous and so varied by the results of secondary actions that it is very doubtful whether the electromotive force measured is that due solely to the union of those atoms which are indicated by the principal equation of the reaction. The method of time, or speed of chemical reactions, has a history as old as that of its two associates, but the story is much less eventful, for very little work has been done in this field. Wenzel held that the affinity of metals for a common solvent, such as nitric acid, was inversely as the time necessary to dissolve them; the attacked surfaces being equal and invariable. He experimented on small cylinders covered with wax except on one of their bases.[29]

The most notable work in this field has been done by Gladstone and Tribe[30] by ascertaining the rate at which a metallic plate could precipitate another metal from a solution; by Berthelot, Menschutkin and others who have studied the time necessary for etherification. The rate of inversion of cane sugar has been investigated by Urech, and in this country by R. B. Warder. The above are only three out of many subjects which have been studied in regard to their time rate. An index to the literature of this subject has been made by one of the members of this section, Professor R. B. Warder, and may be found in the proceedings of last year.[31]

To these general methods for studying the problem of chemical dynamics should be added the investigation of the action of mass by Gladstone, in his well-known color work on the

sulphocyanides of iron;[32] the chemical action of light by the late J. W. Draper,[33] in this country, and Professor H. E. Roscoe[34] in England, as well as Becquerel[35] in France, pioneers who have since been followed by a host of students of scientific photography.

In the review just given no attempt has been made to do more than glance at the important contributions to the theory and methods of measuring affinity. Many names have been passed by and much work has been necessarily ignored owing to the limits of time and space which surround the writer of an address like this; but notwithstanding the presence of those limits, and my consciousness of how greatly your patience has been drawn upon, I will venture to add a few words on one other phase of the subject, and that is *The Existing Problem.*

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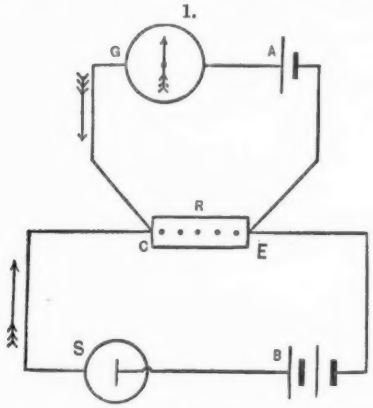
[To be concluded.]

ART. XLV.—*Relation between the Electromotive Force of a Daniell Cell and the Strength of the Zinc Sulphate Solution;* by H. S. CARHART.

THE investigation here described was carried out in the physical laboratory of the University of Berlin in the spring of 1882, and was undertaken with a view to ascertain whether the variation in the strength of the zinc sulphate solution surrounding the zinc plate of a Daniell cell affected the electromotive force, and to what extent.

It is well known that different experimenters have found different values of the electromotive force of a Daniell element. Thus Sir William Thomson found a value of 1·122 volts; Latimer Clark, 1·11; Kohlrausch, 1·138.* These different results may be partly due to difference of method; but it is easy to ascertain that slight changes in the condition of the plates or in the concentration of the solutions modify the value of the electromotive force to an appreciable extent. The method employed in this investigation was essentially the compensation method of Poggendorff.† The two poles of the battery A, the electromotive force of which is required, are



connected with two points C E of a second circuit containing a battery B of higher electromotive force than A. The resistance between C and E is then varied by means of the rheostat R, till no current flows through the circuit of battery A. The difference of potential between the points C and E is then the electromotive force to be measured. By Ohm's law, the product

* Everett's Units and Physical Constants, p. 146.
† Wiedemann's Elektricität, p. 633.

of the resistance inserted between C and E and the strength of the current in the main circuit equals the difference of potential between the two points, or the electromotive force of A.

The current was measured by a silver voltameter (S) with pure nitrate of silver The resistance employed at R was in Siemens units. The deposition of silver was continued for ten minutes; the cup was then washed with great care, dried in a hot air chamber, and weighed after cooling, fractions of milligrams being obtained by observing the swing of the pointer.

The Daniell cell consisted of a U tube of the form employed by Kohlrausch in measuring the resistance of electrolytes,* the bend of the tube being much smaller than the two branches. The lower portion was first filled with a saturated solution of pure zinc sulphate; saturated copper sulphate was then added to one branch and a percentage solution of zinc sulphate to the other. The sulphates were so added that the surface of separation between two solutions in contact was quite clear and sharp. This was effected by first placing a small disc of cardboard on the surface of the liquid in the tube and then carefully pouring the other liquid on it from a pipette. No sensible diffusion took place during the time required to make the observations.

The galvanometer in the circuit of A was a sensitive one and was observed with a telescope and scale at a distance of about two meters. After a little experience a balance was readily obtained by the greater or less immersion of the silver plate in the nitrate of silver solution of the voltameter; and it was tested from time to time during the deposition of the silver and corrected if necessary. The galvanometer never showed a deflection of more than a few scale parts—perhaps five of the millimeter force divisions. The electromotive of A was thus measured with minimum liability to polarization and by a method entirely independent of the internal resistance of the cell. The only resistance required is that between C and E, and this can easily be measured by means of a rheostat.

The temperature of the rheostat and of the cell was observed at every trial. The extreme limits of variation in the temperature of the cell was 3°·2 C.

The table exhibits the results; but the final reduction, as shown in the last column, was not made till after the recent report of the Paris commission on the legal ohm, and the publication of the results of Lord Rayleigh's experiments with the silver voltameter.† The values of the electromotive force, given in the column next to the last in arbitrary units, were reduced to volts as follows:—

* Wiedemann's Elektricität, p. 590.
† Nature, March 20, 1884, p. 495.

TABLE.

Per cent. of $ZnSO_4$	Temp. of R'eostat	Resis. in Siemens Units.	Silver deposited in one minute.	Product of resistance and silver.	Corrected for temp. of rheostat.	Mean value of product.	E. M. F. in volts.
0	20°	11	6·727 mgs.	73·997	73·997	73·997	
1	18·8	11	7·277 "	80·037	80·000	80·000	1·125
3	18	11	7·339 "	80·729	80·664	80·584	1·133
	19·5	12	6·710 "	80·520	80·504		
5	17·8	11	7·423 "	81·653	81·581	81·216	1·142
	17·3	11	7·358 "	80·938	80·851		
7.5	17·3	11	7·239 "	79·632	79·546	79·620	1·120
	18·3	11	7·250 "	79·750	79·694		
10	17	11	7·224 "	79·464	79·369	79·490	1·118
	19·3	11	7·239 "	79·634	79·612		
15	20	11	7·219 "	79·409	79·409	79·305	1·115
	18·3	11	7·205 "	79·255	79·201		
20	17·3	11	7·170 "	78·870	78·785	79·008	1·111
	17·5	11	7·210 "	79·310	79·231		
25	16·3	11	7·199 "	79·189	79·072	78·997	1·111
	16·6	11	7·184 "	79·030	78·923		

Mean, 1·122

The ratio of the Siemens unit to the congress or legal ohm is 100 to 106, or, 50 to 53. According to Lord Rayleigh a current of one ampère deposits 4·025 gms. of silver in an hour, or 67·08 mgs. a minute. Therefore if C, R and E represent current strength, resistance, and electromotive force in ampères, ohms, and volts, and e the electromotive force in the arbitrary unit of the table, we have the following equation,

$$\left(R.\frac{53}{50}\right)(C\times 67{\cdot}08)=e;$$

$$\text{whence } R\,C=\frac{e}{\frac{53}{50}\times 67{\cdot}08}=\frac{e}{71{\cdot}105}=E.$$

It is only necessary then to divide the quantities in column seven by 71·105 to reduce them to volts.

The method employed is amply sustained by the results obtained with a Latimer Clark standard cell. Two trials gave the same result. I give only one of them.

Time of deposition of silver, ... 10 min.
Resistance between C and D, ... 20 S. U.
Temperature of rheostat, ... 19°
" Clark's cell, ... 18°
Weight of silver cup after deposition, ... 26·1963 gms.
" " before " ..... 26·1453 "

Silver deposited in 10 min., ... 0·051 "
" " 1 min., ... 5·1 mgs.

$5{\cdot}1\times 20=102=e.$ $\qquad 102\div 71{\cdot}105=1{\cdot}434=E.$

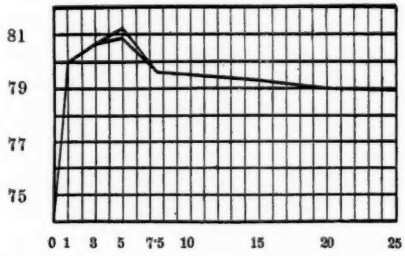
The electromotive force of a Clark element is therefore 1·434 volts, the exact value given by Lord Rayleigh* instead of the formerly accepted value of 1·457 volts.

The mean of all the values of the electromotive force in the last column of the table is 1·122, which is the value obtained by Sir William Thomson by the electrostatic method, if the velocity expressing the ratio between the electrostatic and electromagnetic units be taken as 3×10^{10}.

In figure 2 the results of the investigation are set forth graphically; the ordinates represent the excess of the quantities in column seven of the table above 74, the value obtained with distilled water; while the corresponding abscissæ denote percentages of zinc sulphate. It will be observed that little variation in the value of the electromotive force occurs after reaching ten per cent. of zinc sulphate, and that the maximum value appears to be at about five per cent. I have some reasons for doubting the accuracy of the larger of the two values found with the five per cent. solution. If the smaller value alone is employed the points laid off may be connected by nearly a plane curve.

It thus appears that the variation in the concentration of the zinc sulphate solution is sufficient to account for the larger part of the discrepancy between the results obtained by different experimenters in measuring the electromotive force of a Daniell cell. It would therefore seem desirable that a

2.



standard Daniell element should be so constructed as to admit of employing a zinc sulphate solution of known concentration. The form proposed by Professor G. F. Barker,† in which the solutions are saturated appears to meet the requirements in this respect.

Northwestern University, Evanston, Ill., August, 1884.

* Nature, March 20, 1884, p. 495. In his Montreal Presidential address Lord Rayleigh gave the value 1·435 volts.

† Proc. Amer. Philos. Soc., Jan. 19, 1883, p. 654.

ART. XLVI.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 10; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. LVI.

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Work of the Steamer Albatross in 1884.

THE exploration of the Gulf Stream region was continued this season, under nearly the same conditions as in 1883, by the steamer Albatross, Lieut. Z. L. Tanner, commander. During the four trips, between July 20 and Sept. 13, sixty-nine dredgings (at stations 2170 to 2238) were made. In most of these a large beam-trawl was used very successfully, even at great depths.*

Of these dredgings 5 were in depths between 2000 and 2600 fathoms (4 successful); 20 were between 1000 and 2000 fathoms; 24 between 500 and 1000 fathoms; 8 between 300 and 500 fathoms; 12 between 75 and 300 fathoms. Another trip has since been made to explore extensively the zone between 40 and 100 fathoms. On this trip about 24 additional dredgings were made, but the results are not yet worked out. The first trip was made while the steamer was on her way north from Norfolk, Va., and some of those stations were off the coast of Maryland, the most southern being in N. lat. 37° 57′, but most of the others have been made in the region south and southeast of Martha's Vineyard, though some of them were a long way off the coast. The five stations in depths below 2000 fathoms were more than half way to Bermuda, and nearly east of the coast of Virginia, between N. lat. 36° 05′ 30″ and 37° 48′ 30″; and between W. long. 68° 21′ and 71° 55′.

The results are highly satisfactory, both in the way of physical observations and zoological discoveries. Large numbers of additions have been made to the fauna, including representatives of nearly all classes of deep-sea animals. Many pelagic

* It is but just to say that the unusual thoroughness and remarkable success of these explorations of the Gulf Stream region have been due to the great skill and untiring zeal and energy of Capt. Tanner, who has personally superintended all our deep-sea dredging operations during the past five years. It is proper to add that his efforts have been well supported by the other officers associated with him.

The naturalists associated with the writer in the work, in 1884, were Professor S. I. Smith, Mr. Sanderson Smith, Mr. Richard Rathbun, Professor L. A. Lee, Mr. B. F. Koons, Professor Edwin Linton, Mr. H. L. Bruner, Mr. J. H. Blake (as artist), Mr. J. E. Benedict (naturalist attached to the steamer), Mr. A. Baldwin, W. E. Safford, Ensign U. S N., Mr. Wm. Nye, and others. Mr. Peter Parker and R. H. Miner, Ensign U. S. N., worked on the fishes. The parties who went out dredging on the steamer varied from time to time. Usually not more than three or four naturalists besides Mr. Benedict were sent out.

species were also secured in the surface nets and especially in the trawl-wings. Among these there are some new forms and many that have not previously been observed so far north in the Gulf Stream.

Character of the deep-sea deposits.

Some very interesting and important discoveries were made in regard to the nature of the materials composing the sea-bottom under the Gulf Stream at great depths. These observations are of great interest from a geological point of view and some of them are contrary to the experience of other expeditions and not in accordance with the generally accepted theories of the nature of the deposits far from land. The bottom between 600 and 2000 fathoms, in other regions, has generally been found to consist mainly of "globigerina ooze," or as in some parts of the West Indian seas, of a mixture of globigerina and pteropod ooze. Off our northern coasts, however, although there is a more or less impure globigerina ooze, at such depths, at most localities beneath the Gulf Stream, this is by no means always the case. The ooze is always mixed with some sand and frequently with much clay-mud. In a number of instances the bottom between 500 and 1200 fathoms has been found to consist of tough and compact clay, so thoroughly hardened that many large angular masses, sometimes weighing more than fifty pounds, have been brought up in the trawl, and have not been washed away appreciably, notwithstanding the rapidity with which they have been drawn up through about two miles of water. In fact, these masses of hard clay resemble large angular blocks of stone, but when cut with a knife they have a consistency somewhat like hard castile soap, and in sections are mottled with lighter and darker tints of dull green, olive and bluish gray. When dried they develop cracks and break up into angular fragments. This material is genuine clay, mixed with more or less sand, showing under the microscope grains of quartz and feldspar with some scales of mica. More or less of the shells of *Globigerina* and other Foraminifera are contained in the clay, but they make up a very small percentage of the material.

The following are some of the special localities where these clay masses were taken:

Station 2192, in 1060 fathoms, N. lat. 39° 46′ 30″, W. long. 70° 14′ 45″. Large blocks of sandy clay, some weighing about 100 pounds. It was estimated that about a ton was brought up.

Station 2230, in 1168 fathoms, N. lat. 38° 27′, W. long. 73° 02′. Large quantity of masses of hard but sticky greenish blue clay, some masses varying to yellowish and buff colors.

Station 2171, in 444 fathoms, N. lat. 37° 59′ 30″, W. long. 73° 48′ 40″. Large lumps of bluish gray sandy mud.

In other localities, in 1000 to 1600 fathoms, the bottom is covered with or largely composed of hard, very irregular, flattened, crust-like concretions of clay and iron-oxide, with more or less manganese-oxide in the crevices and worm-burrows with which they are filled. At some localities a barrel-full, or more, of such masses were brought up, varying in size from a few ounces up to 20 pounds or more in weight and from one inch to six inches in thickness.

The following are some of the localities where such material occurred:

Station 2208, in 1178 fathoms, N. lat. 39° 33′, W. long. 71° 16′ 15″. Large quantities of hard crusty ferruginous clay. Also a rounded granite bowlder, weighing over 20 pounds.

Station 2228, in 1582 fathoms, N. lat. 37° 25′, W. long. 73° 06′. Large quantity of irregular crusty and cavernous concretions and masses of ferruginous clay, with considerable black manganese-oxide lining the holes and cracks. The lower side of many of the masses consisted of sticky bluish clay. It was estimated that about a ton of this material came up. There were adhering to these hard masses some corals, gorgonians, hydroids and bryozoa, with the brachiopods, *Discina Atlantica* and *Waldheimia cranium*, in considerable numbers.

Rounded bowlders and pebbles of granite, gneiss and other crystalline rocks occurred at a number of stations. One bowlder, station 2208, is referred to above. The following are other localities: station 2195, in 1058 fathoms, N. lat. 39° 44′, W. long. 70° 03′. A rounded granitic bowlder, about four inches in diameter. Its surface was covered with adherent species of foraminifera and some annelid-tubes. Station 2226, in 2021 fathoms, N. lat. 37° 00′, W. long. 71° 54′. A large number of pebbles and small, rounded bowlders of granite, porphyry, etc., and some coal cinders. The pebbles were more or less covered with adherent foraminifera, bryozoa, etc. Scattered bowlders and pebbles have also occurred at many other localities along the inner edge of the Gulf Stream. These have probably all been carried out there by ice from the adjacent coasts, in spring.

A curious instance, quite unique in our experience, of the occurrence of abundant relics of human handiwork was observed this year. At station 2222, in 1537 fathoms, N. lat. 39° 03′ 15″, W. long. 70° 50′ 45″, beneath the Gulf Stream, a large quantity of common bricks with mortar and soot still adhering to them was brought up in the trawl. Some were nearly entire, but most were in fragments. Annelid tubes,

brachiopods,* and other forms of deep-sea life were attached to them in small quantities, showing that they had not been on the bottom very long. These may have come from some wreck, or they may have formed the deck-furnace of some whaling vessel and have been thrown overboard on the homeward trip. At any rate, the accident of hitting upon the precise locality of such relics is very curious. Otherwise than this instance we have rarely found in deep water any human traces except coal cinders from steamers.

In all our ten localities between 2000 and 3000 fathoms the bottom has been "globigerina ooze." We have never met with the "red clay" which ought to occur at such depths, according to the observations made on the cruise of the Challenger.

The temperatures observed with the improved thermometers now used on the Albatross were between 36°·4 and 37°·00 F. in 2000 to 2600 fathoms. But temperatures essentially the same as these were also taken in 1000 to 1500 fathoms, and even in 965 fathoms one observation gave 36°·8 F. It follows from these observations that nearly the minimum temperature is reached at about 1000 fathoms in this region.

The *zoological results* this year are very important. Many additions to the fauna of great depths were made and a large proportion of them are undescribed forms. Some of the fishes were of great interest. Huge spiny spider-crabs (*Lithodes Agassizii*) over three feet across were taken in 1000 to 1230 fathoms, and another very large crab (*Geryon quinquedens*) occurred in great abundance in 500 to 1000 fathoms, while in 2574 fathoms a large and strong species of *Munidopsis* was taken. Numerous species of handsome shrimp, many of them bright colored and some of very large size occurred, as usual, in the deeper dredgings. Some of these had not been taken before.

Many very interesting Echinoderms have been obtained this year and last, in addition to all those enumerated from the same region in one of my former papers in this Journal. Among these are several Holothurians, besides the two large species, *Benthodytes gigantea* and *Euphronides cornuta* described in my last paper, both of which were taken in abundance this year, the former in 904 to 2033 fathoms, the latter in 861 to 1735 fathoms. One of the new forms belongs to the genus *Ankeroderma*. Of Echini, we have taken two of the species with flexible shells (*Phormosoma placenta* and *P. uranus*) in many localities and in considerable numbers. *P. uranus* occurred in 568 to 1080 fathoms. Some of the specimens are 8 to 9 inches

* One of these brachiopods, which occurred on the bricks in considerable numbers, is *Atretia gnomon* J., which has not been recorded hitherto from off our coast.

in diameter, and of a rich purplish color, an unusual color for deep-sea animals. *P. placenta* ranges from 458 to 1230 fathoms. Other interesting species were *Pourtalesia Jeffreysii*, in 1255 to 1555 fathoms; *Aërope rostrata*, in 1467 to 1608 fathoms; *Aceste bellidifera*, in 1467 fathoms; *Urechinus Naresianus*, in 1309 fathoms; *Salenia varispina*, in 547 fathoms; and *Aspidodiadema Antillarum*. The last had not been taken before north of the West Indies. A large specimen occurred in 991 fathoms. A good specimen of *Rhizocrinus* was taken in 2021 fathoms, station 2226.

The additions to our list of starfishes have been numerous and important during the last two years. Two species of *Brisinga* have been taken in many localities, sometimes in large numbers. One of these has often been obtained and preserved nearly entire. It is a handsome species,* with long slender arms, usually 11 or 12 in number, but varying from 9 to 13. The other is a coarser species,† which usually comes up broken into numerous fragments, by spontaneous division.

* *Brisinga elegans* V., sp. nov. Arms long and slender, usually 11 or 12, but varying from 9 to 13, rounded and finely spinulose toward the base, very slender, angular and transversely ribbed distally. Disk small, round, a little swollen, covered dorsally with small acute spinules, standing singly or two or three together. On the proximal part of the arm the spinules are small and sharp, scattered in small clusters, which are sometimes elongated transversely. These spinules are surrounded by clusters of minute pedicellariæ. A little farther out the spinules and pedicellariæ begin to be arranged in indefinite transverse groups, and still farther out there are regular and rather prominent broad, flattened, sinuous, tranverse groups of pedicellariæ, which extend nearly to the median dorsal angle; these continue to the end of the arm. The arms have on each side a lateral row of long slender spines, covered by fleshy sheaths which are clavate at the tip and bear numerous minute pedicellariæ. The lateral spines are longest at the middle portion of the arms. On each adambulacral plate a single slender, acute spine projects directly inward beyond the middle of the groove, so that those on opposite sides interlock. The ovaries are clustered in the basal part of the arms and discharge by a basal pore on each side. Color in life salmon or pale orange: in alcohol soon becoming yellowish white.

Greater radius, 275^{mm}; lesser radius, 12^{mm}; length of the largest lateral spines, 20–25^{mm}; breadth of arms, where largest, 10^{mm}. Some specimens have occurred larger than this, but the rays were broken.

Taken at station 2035 and at several other localities in 1883, and at stations 2205, 2209, 2211, 2220, 2226, 2229, in 1884, in 906 to 2021 fathoms. At station 2229 about thirty specimens were taken, several of them in good condition.

† *Brisinga costata* V., sp. nov. A large species, usually with eleven arms, closely allied to *B. coronata* Sars. The disk is round, swollen, roughly spinulose, the spines small, sharp, standing singly or in groups of two, three or more. Arms very long, strongly depressed, somewhat swollen toward the base, but broad and angular and carinated farther out, gradually tapering. The basal portion is crossed by curved, sinuous, very prominent, narrow ribs, some continuous and some interrupted, surmounted by a row of small, short spinules. Transvere raised bands of pedicellariæ alternate with the ribs. The adambulacral plates bear usually three slender, fluted, glassy spines in a transverse row at about the middle of the plate, the uppermost longer and larger than the others the third being small and slender; in addition to these there is a smaller, more slender, inner spine, situated at the distal end of each plate and projecting more than half-way across the groove. All the spines bear swollen sheaths of minute pedicellariæ. Diameter of disk, 28^{mm}; breadth of arms, near base, 11^{mm}; length of longest spines, 12^{mm}.

Station 2310, in 991 fathoms (No. 7820), and also from several other localities.

A single large specimen of *Zoroaster fulgens* Thomp. was taken at station 2206, in 1043 fathoms, associated with the much more common *Z. Diomedeæ* V. The two are very easily distinguished. The curious little pentagonal star fish described by Thompson (voyage of the Challenger) as *Porcellanaster cæruleus* was taken in numbers at many localities, both this year and last, in 906 to 1467 fathoms. Its cœrulean color is due only to the bluish mud, with which its large stomach is usually filled, showing through the translucent integument. The real color is buff or pale salmon. *Archaster grandis* V. occurred abundantly in 965 to 2033 fathoms, and *Benthopecten spinosus* V., in 855 to 2021 fathoms. A large and handsome new *Archaster* (*A. robustus* V.)* remarkable for its high, squarish arms and smoothish appearance, was taken both this year and last, at several localities, in 924 to 1467 fathoms. Another new and very elegant species of this genus (*A. formosus* V.)† was taken sparingly in 1594 to 2021 fathoms.

* *Archaster robustus* V., sp. nov. Disk rather small, thick. Arms five, elongated, thick, squarish, with high and nearly perpendicular sides, tapering very gradually from near the base to the rather slender, acute tips. Dorsal surface of the disk and arms almost entirely covered with closely crowded paxillæ, the upper ends of the marginal plates forming only a very narrow margin along the arms. The paxillæ over the central position of the disk are very much smaller and more crowded than on the arms; immediately around the prominent abactinal pore they become remarkably fine and close; over the dorsal surface of the arms and along the margins of the disk they are rather regular in form and of uniform size, each bearing a flattened group of very short, close, blunt spinules. The madreporic plate is small, flat, depressed, situated about one-third the distance from the margin to the center of the disk. The marginal plates are narrow, very high, and each is surmounted by a small, short, conical spine, forming a row along the margin of the arms; laterally they are closely covered by small scale-like spinules, sometimes with two or three small, acute spinules below the middle. The ventral plates are small, densely covered with the same, small, flattened scales. The interbrachial spaces are very small and scaled. The adambulacral plates project inward and each bears an acute group of small, crowded, flattened spinules of which the central one is longest and acute, the other scale-like ones surrounding and supporting it externally. The oral plates form a long, narrow ellipse, each bearing two or more rows of small, short, flattened spinules, those at the inner end becoming a little more prominent but flattened and scarcely spine-like. Ambulacral grooves very broad. Suckers very large, conical, with small, papilliform tips. Color in life light buff or salmon.

A rather small specimen measures from center of disk to interradial margin, 14^{mm}; from center of disk to tip of rays, 66^{mm}; height of disk, 14^{mm}; breadth of arms near the base, 13^{mm}; height of marginal plates, 10^{mm}; diameter of suckers, $2{\cdot}5^{mm}$. Specimens have been taken at least twice the size of the above.

The larger specimens are still more remarkable for the great elevation and squareness of the arms. In very young specimens this feature is less prominent.

This species is easily distinguished from all the others by the high perpendicular sides of the arms, and by the peculiar form and scale-like covering of the marginal and ventral plates.

Taken at many localities, in both 1883 and 1884, in 924 to 1467 fathoms.

† *Archaster formosus* V., sp. nov. An elegant species, with a moderately large pentagonal disk, having regular incurved borders, and rather long arms, quickly becoming nearly round and very slender distally. The arms have, except close to the base, a very narrow median dorsal area, bearing only a single row of paxillæ, and the tip is terminated by a single, elongated plate. The disk is closely cov-

Ophiurans of many species were very abundant in numerous localities. Among those of special interest are *Ophiomusium armigerum*, abundant and large, in 1731 to 2369 fathoms; *Ophioglypha convexa*, in 1608 to 2574 fathoms; *O. lepida?** taken in vast numbers at station 2221, in 1525 fathoms, and common in many other places, in 1168 to 2574 fathoms.

A fine large new species of the genus *Ophiochiton* (*O. grandis* V.)† was taken, both last year and this, in 888 to 1080 fathoms. This genus was not before known in this region.

Art. XLVII.—*Note on the Cortlandt and Stony Point Hornblendic and Augitic rock;* by James D. Dana.

In my paper on the rocks of Westchester County, N. Y., I described certain massive hornblendic and augitic rocks, for the most part chrysolitic, from the town of Cortlandt and from

ered with rather large, angular paxillæ, those in the center becoming much smaller. The paxillæ bear close clusters of short, thick, obtuse or rounded spinules, about 30 to 36 on the largest. The dorsal marginal plates are higher than broad, except distally; they are regular, little convex, and covered with small, flattened granules. The lower plates are similar to and opposite the upper ones, their upper half bearing granules which change to small sharp spinules lower down, and in some specimens several longer spinules are developed on the central part of some of the plates. The ventral areas are small and covered with rather large plates, which bear small obtuse spinules, a somewhat larger one usually occupying the center of each plate. The adambulacral plates project strongly inward with deep notches between them. Each bears a convex group of six to eight slender spinules directed inward, while on the middle of the plate there is a group of eight to ten smaller, rough, divergent spinules. Color in life pale buff.

Greater radius of one of the largest specimens, 74^{mm}; lesser radius, 18^{mm}; breadth of arms in middle, 6^{mm}.

This species was taken in 1883 at stations 2041, 2042, 2043, in 1467 to 1608 fathoms; and in 1884 at station 2174, in 1594 fathoms (No. 7963); and station 2226, in 2021 fathoms (No. 8151), three specimens.

* This resembles *O. lepida* Lym., but the disk is sparcely covered with small slender spines. It may be designated as var. *spinulosa*.

† *Ophiochiton grandis* V., sp. nov. A large species with the disk rounded, carinated at the margin, its surface covered with numerous unequal imbricated plates, becoming larger and more distinct toward the margin. The radial plates are rather small, well-separated, with the inner ends strongly divergent, irregularly ovate in form. The arms are long, stout, depressed, distinctly medially carinated below, less so above. The arm-spines are three, rather long and tapered, the upper one longer than the other. The tentacle-pores are large and each has one large, round, flat scale. The ventral arm-plates are broader than long, emarginated laterally with the outer corner elongated and acute, an obtuse prominent lobe in the middle of the outer margin. Oral plates prominent, convex, rather small, ovate, the outer edge broadly rounded, the inner end acute, the sides a little incurved. Mouth papillæ five to seven, the outer ones much broader and flatter than the inner ones, which are conical and acute. A similar median papilla stands above the teeth. Color in alcohol dull yellowish brown.

Diameter of disk, 30^{mm}; breadth of arms at base, 4·5^{mm}; length of longest arm-spines, 3·5^{mm}.

Stations 2209, 2217, in 924 to 1080 fathoms, 1884; station 2116, in 888 fathoms, 1883 (No. 6624).

Stony Point on the opposite shore of the Hudson. I showed, by the occurrence of dikes in the limestone of Verplanck and other peculiarities, that they were once in fusion or a plastic state; but I suggested that the fusion may have been connected with the metamorphic action that crystallized the rocks of the region, and that the peculiar constitution of the rocks may have come from previous igneous ejections and tufaceous deposits.

Since the publication of my paper, a north-and-south cut has been made through the rocks of Stony Point for the "West Shore" railroad, and it is now clear that these rocks are of true *eruptive* origin. The line of the railroad extends southward along the shore just east of Dunn's house (see map on page 112 of vol. xxii of this Journal for August, 1881*), and continues in nearly the same direction across the Point, passing through, in succession, the "soda granite,"† the chrysolitic rock and the mica schist. The exposed section of the chrysolitic rock (which is mainly chrysolitic hornblendyte) is about 250 yards long. In the section it appears to constitute a dike about N. 60° E. or S. 60° W. in course; but the map shows that the mass extends at the surface hardly a hundred yards west of the railroad, the mica schist being the surface rock beyond this distance.

The mica schist (a gneissoid mica schist) exposed to view in the railroad cut south of the igneous mass becomes increasingly flexed as it nears the dike; but this increase of flexure in its beds has nothing to do with the eruption of the hornblendyte, while it has some connection with the origin of the soda-granite, as shown near Cruger's on the east side of the Hudson.

The *south* wall of the dike or erupted mass, or the plane of contact with the mica schist, has a strike of about N. 55° E., and dips 80° to the northward. Some effects of the heat from the melted rock appear in the schists, and among them there are in a few places greenish spots or nodules.

The *north* wall of the chrysolitic hornblendyte mass is not well exposed to view but appears to be nearly vertical. Against it there is, first, for about thirty-five feet, *limestone* which is in part a very coarse limestone-breccia having the igneous rock as its cement, but in places shows nearly vertical bedding, parallel nearly to its junction with the next rock north, the soda-granite. This breccia contains large angular masses of limestone, and resembles the limestone breccia of Verplanck Point (described on pages 201 and 202 of volume xx of this Journal, September, 1880), in its appearance, its cement and the very small effect of heat at the contacts with the cement beyond some mutual impregnations. The limestone at Verplanck

* The scale of the map is 800 feet to the inch.

† The "rock" I have since named *hemidioryte*, the name often used in lithology, micadioryte, being bad.

Point is the same that outcrops elsewhere on the Point, and is evidently the eastern part of the formation largely exposed on the west side of the river from the base of Stony Point to and beyond Tompkins Cove; and it is hence safe to conclude that the limestone by the side of the Stony Point dike is a portion of the Tompkins Cove formation.

The junction plane of the limestone and soda-granite has the direction N. 70° E., and dips 67° to the northward; and but for the intervening limestone it would be regarded as the north wall of the dike. North of the dike, along the section, the soda-granite is intersected by blackish, narrow veins or vein-like dikes, a foot or so wide, two of which cross one another like the bars of the letter X. There is also a dike of the chrysolitic hornblendyte eighteen feet wide.

While the facts prove the hornblende rock and the related augite rock to be eruptive, they throw no new light on the origin of the "soda-granite." They show, like the facts from Verplanck Point, that the igneous eruptions took place *subsequently* to the era of the limestone, mica schist and soda-granite. And the limestone is, as I have proved, younger than the Archæan of the Highlands, and probably of Lower Silurian age, as recognized for the Tompkins Cove limstone by Professor G. H. Cook.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *National Conference of Electricians.*—On the 17th of July, the President of the United States, in pursuance of an act of Congress, appointed an Electrical Commission charged with the duty of conducting, in the name of the United States Government, "a National Conference of Electricians in Philadelphia in the autumn of eighteen hundred and eighty-four." This Commission consisted of the following persons: H. A. Rowland, M. B. Snyder, J. Willard Gibbs, John Trowbridge, C. A. Young, C. F. Brackett, W. H. Wahl, Simon Newcomb, G. F. Barker, E. J. Houston, R. A. Fisk and F. C. VanDyck. The Commission met on the 9th of August, completed its organization and sent out invitations to about one hundred and fifty American and to twenty-four foreign men of science, asking them to take part in the Conference above mentioned. The Right Hon. Lord Rayleigh, the Right Hon. Sir Lyon Playfair and Professor Sir Wm. Thomson were invited to act as Vice-Presidents of the Conference.

On the 8th of September, the National Conference of Electricians met at 3 o'clock P. M. The meeting was formally called to order by Professor Simon Newcomb, who introduced the Presi-

dent of the Conference, Professor Rowland. His opening address, which occupied nearly an hour in delivery, was mainly an exposition of the progress of electrical science viewed from the standpoint of theory. After a glowing eulogium of Archimedes, the man who, according to Plutarch "possessed so high a spirit, so profound a soul and such treasures of scientific knowledge that though the inventions (referring to his military engines) had now obtained for him the renown of more than human sagacity, he yet would not deign to leave behind him any commentary or writing on such subjects; but repudiating as sordid and ignoble the whole trade of engineering and every sort of art that lends itself to mere use and profit, he placed his whole affection and ambition in those purer speculations where there can be no reference to the vulgar needs of life; studies, the superiority of which to all others is unquestioned and in which the only doubt can be whether the beauty and grandeur of the subjects examined or the precision and cogency of the methods and the means of proof, most deserve our admiration"—he discussed the relation of the investigator to the inventor. "Pure science must exist before its applications, and the truths of pure science are far more reaching in their effects than any of its applications; and yet the applications of science often have a much more immediate interest for the world at large than many discoveries in pure science which will finally revolutionize it both physically and mentally. They both have their importance and both are at work in causing that intellectual and material progress in which the world is now pushing forward with grand steps." "The simple experiment of the amber remained without investigation for 2200 years. Had the reasoning of many modern persons been followed we should never have had a science of electricity. Why should anybody investigate this phenomenon, this feeble force which could only attract a few particles of dust? The world could eat, drink and take its ease without doing anything in the matter and it did so for more than 2000 years of intellectual, moral and physical degradation. Then the awakening came and men began to feel that they were reasoning beings. They began to see that there were other pleasures in the world besides animal pleasures, and that they had been placed in this wonderful universe that they might exalt their intelligence by its proper study. No question of gain entered into the minds of these early investigators, but they were led by that instinct toward truth which indicates the highest type of man." "The name of Faraday needs no eulogy from me, for it stands where it can never be hidden and the spark which Faraday first kindled now dazzles us at every street corner. No wealth came to him although he had only to hold out his hand for it. But the holding out of one's hand takes time which Faraday could not spare from his labors and so the wealth which was rightly his went to others. Who will follow in his footsteps and live such a life that the thought of it almost fills one with reverence? It is not only his intellect which we admire; it

is his moral qualities which fill us with awe, his noble and unselfish spirit." The address then passed to consider the progress of electrical measurement, the necessity for a governmental bureau of electric standards and the vexed question of the nature of electricity, closing with a few well chosen words on the relation of theoretical to applied science. "Let not then the devotee of pure science despise practical science, nor the inventor look upon the scientific discoverer as a mere visionary person. They are both necessary to the world's progress and they are necessary to each other. To-day our country by its liberal patent laws encourages applied science. We point to our inventions with pride and our machinery in many of the arts is not surpassed. But in the cultivation of the pure sciences we are but children in the eyes of the world. Our country has now obtained wealth and this wealth should partly go in this direction. We have attained an honorable position in applied science and now let us give back to the world what we have received in the shape of pure science. Thus shall we no longer be dependent but shall earn our science as well as inventions. Let physical laboratories arise; let men of genius be placed at their head, and best of all let them be encouraged to pursue their work by the sympathy of those around them. Let the professors be given a liberal salary, so that men of talent may be contented. Let technical schools also be founded and let them train men to carry forward the great work of applied science. Let them not be machines to grind out graduates by the thousand irrespective of quality. But let each one be trained in theoretical science, leaving most of his practical science to be learned afterward; avoiding, however, overtraining. Life is too short for one man to know everything, but it is not too short to know more than is taught in most of our technical schools. It is not telegraph operators but electrical engineers that the future demands. Such a day has almost come to our country and we welcome its approach. Then and not till then should our country be proud and point with satisfaction to her discoveries in science pure and applied, while she has knowledge enough to stand in humiliation before that great undiscovered ocean of truth on whose shores Newton thought he had but played."

Professor Sir Wm. Thomson followed with a few remarks, in which after endorsing the line of thought in the address just delivered, he considered the great advantages likely to flow from the Conference, particularly in the direction of international standards and an International Bureau. The necessity for exact instruments of measurement prompt and reliable in their indications is every day increasing, and these instruments must measure the hundred thousandth or the millionth of an ampère as required by Langley, or the five thousand ampères needed in an Edison central station. He closed with a cordial eulogy of Joseph Henry.

The Conference continued in session through the entire week. The subjects brought forward were: "Work of the U. S. Signal Service in relation to Atmospheric Electricity and Earth Cur-

rents," the discussion being opened by Professor Abbe and Lieutenants Greely and Allen. "The Adoption of the International Electrical Standards," discussion opened by Professor John Trowbridge. "The Establishment of a National Bureau of Physical Standards," discussion opened by Professor Snyder. "The Theory of the Dynamo-electric machine," discussion opened by Professor Rowland. "The Electrical Transmission of Energy," "Storage Batteries." "Measurement of Large Currents." "Induction in Telephone Wires, Long Distance Telephoning, and Underground Wires." "Applications of Electricity to Military and Mining Engineering," "The Electrical Investigation o the Physical Qualities of Structural Metals," discussion opened by Capt. O. E. Michaelis. "Lightning Protection."

The Committee to which was referred a communication from Gen. Hazen, Chief Signal Officer, on Atmospheric Electricity and Earth Currents, consisting of Professor Abbe, Lieutenant Allen, Professor Trowbridge, W. W. Jacques, F. N. Gisborne, W. H. Preece and Professor Nipher, made a preliminary report on Friday, as follows: "The Committee recommends to the National Conference and to the United States Electrical Commission: (1) That the Government be urged to take steps to secure on a large scale observations of atmospheric electricity and the strength of earth currents. (2) That the methods of observation and reports conform as far as possible with those about to be disseminated by the International Bureau of Telegraphic Administration at Berne. (3) That the Government appoint a permanent Committee of five electricians to coöperate with the Chief Signal Officer of the Army in organizing this service, and (4) That this Committee shall include, besides others, the electricians of prominent companies, such as the Western Union Telegraph and the Bell Telephone Companies and others of wide experience."

The Committee to which the Standard of Light was referred consisted of Professor John Trowbridge, W. H. Preece, Professor E. C. Pickering, Professor C. R. Cross, Professor G. F. Barker, Mr. T. A. Edison and Major Heap, U. S. A. The Committee on the establishment of a National Bureau of Physical Standards consisted of Professors Newcomb, Rowland, Wead and W. A. Rogers. The latter Committee reported on Thursday as follows: "Whereas the recent rapid development of the applications of electricity requires the adoption and legalization of common standards of electrical measures to form the basis of contracts for the supply of electricity; and whereas the realization of such standards requires that all instruments for electrical measures be tested and verified by one central authority: Therefore, be it Resolved, That this Conference deems it of national importance that Congress, in pursuance of its constitutional authority to fix a standard of weights and measures, should fix standards of electrical measures, and in order to secure the use of said standards should establish a Bureau charged with the duty of examining and verifying instruments for electrical and other physical measurements. Resolved, That

the President of this Conference be requested to communicate the above resolution to Congress through the proper official channels. Resolved, That the U. S. Electrical Commission conducting this Conference be requested to appoint a suitable committee to represent the Conference before Congress and to move for such legislation as will secure the object of these resolutions."

Extended discussion was had upon accepting the results of the International Electrical Conference held in Paris. With regard to the ohm, Mr. A. L. Kimball gave the results of Professor Rowland's experiments as 106·278 centimeters for the length of the column of mercury one square millimeter in section which has one ohm resistance; and Sir Wm. Thomson said he thought if the Paris Conference had had this result before them, it would have adopted 106·2 in place of 106. But this value is only provisional and the discussion may in a few years be reopened. The discussion on Dynamo-machines was the fullest of the session, that on Secondary Batteries coming next to it. The results of the Conference cannot fail to be of great value to electrical science, and a more frequent interchange of views similar to this in its character must contribute materially to a healthier and more rapid progress.

The Conference adjourned on Saturday, Sept. 13th, subject to the call of the chairman.*

2. *Determinations of Vapor density of bodies with low boiling points and bodies with high boiling points.*—Nix von Klobakow reviews the methods of previous observers and describes an apparatus for the determination of the vapor density of substances with low boiling points, which in its general features resembles a weight thermometer. The details are fully described in his paper. By means of this apparatus one can work with a very small quantity of the substance. If the weighing of the substance can be depended upon to the fourth decimal place five milligrams of the substance will give precise results. He terms the instrument a vapor density dilatometer. In order to obtain the vapor density of substances which have high boiling points he used an apparatus which can be described as an aräometer, a glass vessel with an opening at its lower part, which allows a part of the liquid which fills the aräometer to flow out, when the vapor or air or gas which fills the upper portion of the aräometer expands. This aräometer is connected with a weighing apparatus which enables one to measure the pressure of the enclosed vapor. This instrument is called a vapor-density aräometer. The results obtained by both instruments agree closely with the results obtained by calculation.—*Ann. der Physik und Chemie*, No. 8, 1884, pp. 466–510. J. T.

3. *Normal elements for Electrometric measurements.*—The need of a suitable practical unit of electromotive force has long been felt. The zinc and mercury element of Latimer Clark is very

*The New York Electrical World published a very full and accurate report of the proceedings of the Conference, to which we here acknowledge our indebtedness.

useful, but its electromotive force is found to change with the temperature, and also to undergo modifications when the cell is short circuited. A Daniell cell suitably prepared can be made to give an electromotive force of about one volt; but in the form of cell in which a porous cup is employed diffusion is constantly going on and thus modifying the electromotive force. A water battery is generally employed to charge the quadrants of an electrometer but the electromotive force of such an element changes after a short interval. Beetz found the electromotive force of a zinc copper element filled with spring water to be 0·992 volt. On examining three cells of his water battery which had been standing a year, he found the following differences of potential 0·838, 0·678, 0·724, giving a mean of 0·743 volt. Beetz proposes the following new form of cell for constant electromotive force: "Fine alabaster plaster of Paris is mixed with concentrated sulphate of copper solution to about the consistency employed in making plaster casts, and some more with concentrated zinc sulphate solution. A U-shaped glass tube, of 4^{mm} diameter and with legs 22^{cm} long was partly filled with the one paste, and after it had set was filled with the other, so that the two were in close contact. A copper wire was introduced into the copper paste before it had set, and a zinc wire into the zinc paste. The upper part of each leg was cleared from plaster and filled up with paraffine." This cell gives an electromotive force of about 1·056 volt. It is practically uninfluenced by change of temperature and by short circuiting. This cell promises to be very useful in all observations with a quadrant electrometer, especially when this instrument is used for continuous registration of atmospheric electricity.—*Ann. der Physik und Chemie*, No. 7, 1884, pp. 402–410. J. T.

4. *Wave-lengths in the Infra-red portion of the solar spectrum.*—The method of phosphorescence used by Henri Becquerel enables one to see at a glance the whole region which is under investigation, and Becquerel claims that the method allows the observer to explore the region further than by means of photography, and in this respect is not exceeded by the bolometer or thermopile. With a very sensitive phosphorescent agent the details of the infra-red region can be observed by the phosphorescent method far better than by Langley's bolometer. The method employed is to throw a beam of light upon a diffraction grating. The rays were concentrated by a lens, they then traversed a bisulphide of carbon prism whose sides were normal to the slit and the lines of the grating, and formed upon the phosphorescent substance a series of oblique spectra in which the radiations with spectra of different orders were juxtaposed and not superposed. The slit was sufficiently narrow to enable one to see clearly the principal lines of the luminous spectra, and by comparing the position of the lines and bands of the infra-red of the first spectra with the known lines of the second and third spectra one could obtain their wave-lengths. A table of wave-lengths is appended to the author's paper.—*Comptes Rendus*, Sept. 1, 1884, pp. 418–420. J. T.

II. Geology and Natural History.

1. *Untersuchungen über die Entstehung der altkrystallinen Schiefergesteine* mit besonderer Bezugnahme auf das Sächsische Granulitgebirge, etc., von Dr. Johannes Lehmann. 278 pp. 4to, with five plates on copper, and an atlas of 28 plates containing 159 photographic representations of rock structures. Bonn: 1884. (M. Hochgürtel.)—This work is a most important contribution to the literature of metamorphism. Whether we entirely agree with the conclusions of the author or not, we cannot fail to be impressed with the amount of material collected as the result of nine years of careful work, the skillful arrangement of this material so as to lead logically to the conclusions reached, and the relation which the author has discovered between some of the most diverse geological phenomena—exhibited by the crystalline schists, by viewing them from a single stand-point. Further, he is careful to distinguish between what is fact and what theory. Although probably few geologists would at present be willing to accept the extreme application of all the principles enunciated, all will find much in the book to agree with their own observations.

The key-note of the whole work is the influence of orographic forces in regional rock metamorphism, which, using Lossen's term, the author designates "*Dislocation metamorphism.*" Where rocks are most tilted and crumpled, there they are most highly crystalline. The action of pressure is twofold according as it affects the *mineralogical composition* or the *structure* of the rock-mass. In nearly every case the two processes go hand in hand. It is conclusively shown how abundantly secondary mica, especially biotite, is developed wherever the rocks have undergone crushing or sliding; and other minerals, such as andalusite, quartz, garnet, rutile, etc., often appear to have a similar origin. By the same means pyroxene is converted into hornblende, as is admirably illustrated in the gabbros of Rosswein and Penig in Saxony.

But of greater importance are the structural alterations which enormous pressure may produce. Heim and others in Switzerland have shown that, when enclosed on all sides, even rocks may be moulded like a viscous mass. Lehmann advocates rather a plasticity, like that of wet clay, produced by a crushing and sliding of the smallest particles upon each other and a re-cementing by abundant mineral secretions. In this manner, a tightly enclosed mass may, both by stretching and compression, be converted, not only into a perfectly schistose rock, but even into one whose constituent minerals are arranged in parallel bands or layers. Hence the possibility of the change of eruptive masses into schists. As Professor J. D. Dana maintained as long ago as 1843, so Dr. Lehmann considers schistose structure in a crystalline rock as no evidence whatever of sedimentation. He therefore agrees with Naumann in considering the Saxon granulite area of erup-

tive origin. He goes so far as to state that even the most complicated system of intertwining dykes may by pressure be altered to a conformable series of schists. According to the author's view, the granulite was originally an intrusive mass which impregnated the surrounding sediments and locally metamorphosed those at a greater distance, but itself cooled far below the surface. Subsequently, when the area was raised to a mountainous tract, it was forced upward in a solid state by pressure, which at the same time imparted to it its schistose and banded structure, while it converted the impregnated slates into gneisses and the others into mica schists.

The extensive role attributed to sediments, broken and again cemented by eruptions of granitic material, thus forming rocks which are neither purely igneous nor yet altogether sedimentary in their origin, is very interesting, but can be only barely mentioned here. Important also are the conclusions arrived at by the author that the petrographical character of a crystalline rock is no criterion of its age, and that essentially the same product may be formed by the regional metamorphism of rocks originally entirely different in their characters. For instance, certain sericite schists he regards as produced from acid eruptive rocks, while others, indistinguishable from them, were once sediments.

Little justice can be done to this elaborate memoir, whose every page is full of suggestion, in the present short notice, and hence only a few of the most important results are here alluded to. Stated by themselves they may seem somewhat startling; for their justification as well as for that of many more of almost equal interest, we can only refer the reader to the work itself, which, whatever be one's geological beliefs, cannot but repay a careful perusal.

In conclusion, too high praise cannot be bestowed upon the photographic illustrations of rock structures, taken in part by transmitted light from but little magnified microscopic sections, and in part by reflected light from carefully polished hand specimens; they permit of a study which is hardly less satisfactory than would be that of the original specimens. G. H. W.

2. *Note on the origin of bedding in so-called metamorphic rocks*, by JAMES D. DANA.—The views presented in the work of Dr. Lehmann, noticed above by Professor G. H. Williams, are of so much interest that I add here some illustrations of the chief point from my observations in America, where metamorphic rocks are exhibited under very varied conditions over large areas. In 1843 (as Prof. Williams states), previous to making these observations, having but a year before arrived in this country after four years abroad spent partly among volcanic islands of the Pacific and on portions of its volcanic borders, I put forth the hypothesis that granite areas had been volcanic centers, and that the gneisses, or schists, about such an area were portions of the volcanic outflow.* At that time I thought well of the new idea, for I had seen volcanic rocks that were schistose. Wider experi-

*This Journal, xlv, 104.

ence among the metamorphic rocks of New England soon satisfied me that the conclusion was wrong, and consequently, it is nowhere repeated in any of my later publications.

It is true that a schistose structure may be induced by pressure. But the question is—How far is this a fact in regions of gneiss and other bedded crystalline rocks. The following facts bear on the question.

(1.) A dozen miles east of New Haven, Conn., at Stony Creek, a thick bed of rock varies laterally in the course of a few rods (as in many other places in the region) from granite to gneiss, and then, between layers of the gneiss, there is a bed of black mica schist, made mostly of black mica or biotite. The beds are nearly horizontal. It looks like stratification.

(2.) From five to nine miles west of New Haven, a fine-grained, garnetiferous mica schist is the surface rock. Going westward, it first bends in a synclinal as shown by the divergent dips; then a mile beyond, in an anticlinal (large granite veins occurring along the axial region), and ends at Derby, where the dip is 90° to 80° W. Beds of feebly crystalline limestone occur in this range of mica schist, and show by their position, that the schistosity conforms to the bedding. The garnets increase in size westward from a diameter of $\frac{1}{20}$ in. to $\frac{1}{8}$ in., and the schist becomes concurrently coarser, yet nowhere coarse, illustrating well one of the principles recognized by Dr. Lehmann—and by the Professors Rogers, geologists of Virginia and Pennsylvania, more than forty years since.

At Derby the mica schist ends by alternating in thin layers with gneiss; the garnets in the first gneiss layers enlarge to $\frac{1}{4}$ to $\frac{1}{2}$ inch; the gneiss becomes coarser to the westward and varies from common to porphyritic. Then follows, with perfect parallelism in bedding, a great formation of coarse gneiss, the most of the gneiss porphyritic, with the feldspar crystals as large as the thumb, and other portions of it coarsely micaceous.

The case looks like one of stratification, of successive deposits or strata, with repeated interstratification at their junction.

(3.) The gneiss formation which commences at Derby continues westward with much mica, free schistosity, and eastward dip—the dip indicating a synclinal at Derby. Three to six miles west of Derby it bends over in a very gentle anticlinal, the eastward dip diminishing first to 20° and then to 10° and less, and the beds continuing nearly horizontal for more than two miles, after which they pitch westward and so continue farther west. In the axial region of this anticlinal occur nearly horizontal beds of crystalline limestone, one of them large, with gneiss in layers conformable to it above and below; and to the south in the town of Trumbull, the limestone is 100 feet thick, and some hornblendic schist in places adjoins it.

Here is unquestionably true stratification, the limestone stratum setting aside all occasion for doubt. Pressure bends and displaces rocks; but it does not insert limestone beds, or make them out of gneiss.

(4.) In northwestern Connecticut, a mile north of the Lime Rock railroad station (and in view from it), a bluff of crystallized limestone, about 300 feet high above its base, is capped by a stratum of coarse garnetiferous, staurolitic mica schist; the two rocks are nearly horizontal in position. As doubts are easy, I may add that I have been up the front and over the top.

Here is stratification, beyond question. And as the same limestone continues far northward into Berkshire without interruption, and the same schist makes or caps ridges through the limestone area as far as it goes, it is true stratification as far as these rocks go. To pressure are owing the flexures and other mechanical effects, and to friction from displacement and the attending pressure the crystallization, as has long been recognized, and nothing else.

(5.) In many parts of western Massachusetts or Berkshire County, and in Canaan, Connecticut, crystalline limestone, mica schist, and the kind of sandstone called quartzyte (for all the quartzyte shows the sand grains and the most of it is well-bedded) occur interstratified, lying in nearly horizontal beds and in bold flexures, as parallel with one another as the boards in a pile. Some of the quartzyte is a conglomerate. The same rocks extend together, far into Vermont, with the same relations as to position.

All this looks like stratification, and stratification of great wide-spread formations, not as the bedding effects of pressure on rocks within "tight" or confined limits. No appeal to the compression of a region of dikes and veins accounts for any one feature of the region.

(6.) In the towns of Rutland, Sudbury, Whiting, Middlebury and others, in central Vermont, the crystalline limestone, which is a part, by direct continuation, of that of Berkshire, and is accompanied by the same quartzyte and mica schist, contains fossils; and, in the belt of West Rutland valley, fossil corals, crinoids and shells of mollusks occur in some of the layers, while others afford some of the best of Vermont marble and contain its largest marble quarries. The mica schist on the west side and the black slate on the east of the West Rutland limestone are conformable with it in bedding. In central Vermont, moreover, the quartzyte adjoining the limestone region has afforded fossils.

Here is decided stratification of beds of sedimentary origin—beds of fossiliferous limestone (now crystalline), of quartzyte or sandstone and of mica schist—as true stratification as in any region of stratified rocks over New York and the States west.

(7.) In some Pennsylvania valleys numerous iron ore beds (limonite or brown hematite) occur in the limestone of what the Geological Survey calls No. II, or that corresponding to the Calciferous, Chazy and Trenton groups (Lower Silurian); and they are situated for the most part near the junction of the limestone (a rock upturned in flexures) and the overlying and bordering slates. The above-mentioned age of the limestone and of the slates has been determined from their fossils.

Along the eastern border of the State of New York, through the towns of Amenia, Northeast, Ancram, Copake and Hillsdale, occur in the valley region west of the Taconic Range, in a limestone belt, similar deposits of iron ore to those of Pennsylvania, having the same features and indicating a like method of origin; further, they are situated mostly near the junction of the limestone and the overlying slates; and the limestone in the part of the same belt between Copake and Poughkeepsie contains fossils of Calciferous and Trenton age.

The evidence of true stratification and for the Lower Silurian age of the beds is as good for the New York region as for the Pennsylvanian; and yet the limestone is more or less crystalline, and the slates are garnetiferous mica schists.

In conclusion I observe that the study of the stratigraphical relations of so-called metamorphic rocks is not solely a study of the beds of a slate, or of a gneiss, or of a mica schist or other single rock, but of the relations of extensive formations of gneiss, mica schist, hornblende schist, quartzyte or limestone and other rocks, to one another; and where such an investigation is undertaken, the geologist will have no occasion long to doubt whether he is studying *stratified* rocks or not. I have never yet examined any gneiss without finding good evidence that it was part of a stratified series. The doubts that have arisen have related to formations of granite, syenyte, dioryte, granulyte, which rocks are known to be sometimes of igneous origin.

Dr. Lehmann's deductions as to the conversion of dikes and veins by pressure into ambiguous strata, and as to the production of schistose bedding in granulyte and like rocks by plasticity in a confined area, have a very limited application; and no experienced geologist ought to be deceived by such an occurrence.

3. *Geology of Centre County, Pa.;* by E. V. D'INVILLIERS; Appendix A, Extracts from Report to Lyon, Shorb & Co., by J. P. LESLEY; Appendix B, Observations on the Geological formations of Centre County, by A. L. EWING. 464 pp. 8vo, with a colored geological map and other illustrations. Pennsylvania Geological Survey, Report T4.—Mr. D'INVILLIERS describes in this report the coal-measures of Centre County (the central county of Pennsylvania), and also the iron ore (limonite) deposits, the latter partly from investigations by F. Platt, A. S. McCreath, W. G. Platt, J. W. Harden, A. L. Ewing and Professor J. P. Lesley.

The colored geological map shows that the county has its coal-measures on the western border, stretching northeastward; and east of them, nearly in parallel position (determined by flexures of the strata), belts of Lower Silurian limestones (Calciferous, Chazy and Trenton combined) between other belts of Hudson River shales and Upper Silurian, the Devonian coming in on the northwest between these rocks and the Carboniferous. The mines or ore-pits of limonite are situated in the limestone belts in Nittany, Penn's and Brush valleys. Mr. d'Invilliers describes the iron ore as chiefly derived from the oxidation of iron in sand-

stone beds in the lower part of the limestone formation. The position is said to differ from that of the beds in the Lehigh region and the Great Valley, which have furnished the bulk of the material to the Lehigh and Schuylkill furnaces, these lying either between the Potsdam and the overlying limestone or between the limestone and the overlying Hudson River shales—which shales are damourite schists (hydromica schists) in southeastern Pennsylvania. The iron from some ore deposits in which sulphur occurs, is inferred to be from pyrite, but in most cases, as its purity appears to indicate, from iron in the condition of carbonate. The deposits are very irregularly distributed, and often have limestone in the walls, with much clay and sand (decomposition products) over the ore.

Professor LESLEY, who has long studied the ore beds, speaks of "shafts passing through soft beds of ore and hard ribs of limestone;" of the ore beds in one place "visibly interstratified with the soft clay and solid limestone layers, obeying the strike and dip;" and with regard to a large and typical ore bed, the "Pennsylvania Furnace ore-bank," he observes that the various irregularities in the deposits are owing to chemical changes and consequent changes in bulk in the strata, during the process of oxidation and solution in progress, in which the looser calciferous and ferriferous layers lost their lime constituent, packed their sand and clay, and oxidized and hydrated the iron, thereby excavating caverns, depositing the iron precipitates as ore, and causing settlings and movements of the overlying material, but without much disturbance of the general stratification. "Only such clay-sand-lime-iron deposits as were properly constituted (originally) have been so completely dissolved as to permit the lime to flow off and the iron (oxidized and hydrated) to consolidate into ore." Every stage and phase in the change presented "in other parts of the Appalachian belt from Canada to Alabama may be seen and studied in these ore banks of Pennsylvania Furnace." At one place sixty feet below the sod, "a shaft was sunk forty feet through solid pipe ore, and then limestone." "The tops of pyramids of solid ore are exposed in the floor, and some reach to, or nearly to, the sod above."

Professor EWING states that the "formation No. II," with which the ore deposits are connected, consists below of sandstone and arenaceous limestone, and above of a blue argillaceous limestone; that it is most magnesian or dolomitic below, but that dolomite and limestone succeed each other in many alternating layers. He concludes that the iron of the iron ore was derived from the limestone, in which it had existed as a ferrous carbonate; that part of the limestone affords on analysis one to two per cent of iron, and that this is sufficient for the production of the largest ore beds; that the sand has come from arenaceous limestones, or calcareous sand-rocks rather than from sandstone, and the clay from argillaceous limestones and intercalated shale; that the oxidation of the iron took place *in situ;* that some small

amount of transportation by flowing waters may have occurred, as the ferrous carbonate is soluble in carbonated waters. At a quarry near by a body of ore, *Trenton fossils* were found, and not over forty rods off occur the Hudson River shales, so that the ore in that case is within 300 or 400 feet of the top of the Trenton limestone formation; and this ferriferous horizon there extends along the strike of the rocks for about forty rods.

The volume is an especially important contribution to the subject of limonite-beds and limonite making. J. D. D.

4. *Note on the making of Limonite ore beds;* by J. D. DANA. —The results of the Pennsylvania geologists accord well with those the writer has obtained from the study of many of the ore-pits of western New England and the eastern border of New York. As Professor Lesley observes, the conditions, the changes and the results are the same throughout. The source is, in both, chiefly the limestone of the Lower Silurian, along the borders of which are overlying Hudson River slates. For the sake of comparison, the writer here states in brief his own conclusions, reserving details as to facts for another place.

(1) The iron ore deposits occur in the limestone near, or adjoining, either the main belt of slate or schist, or intercalated layers or small flexures of it.

(2) The iron for the ore was derived from the limestone and only to a small extent from the slate.

(3) The iron existed in the limestone as carbonate; probably as a carbonate of calcium and iron, or of calcium, magnesium and iron, or of iron alone (siderite), which compounds were mixed with the dolomite or calcite to make the limestone. Manganese was often also present in the ferriferous carbonate. The massive unaltered iron-carbonate outcrops over portions of the lower part of the ore-pit of Amenia, N. Y., of Ore Hill in Salisbury, and at the Leete ore bed in West Stockbridge, and has been found sparingly in other ore pits; its limit downward is unknown.

(4) The ferriferous limestone, owing to its iron and its porosity, undergoes rapid oxidation and decay. The iron-carbonate, because of its compactness, oxidizes slowly at surface and in its rifts; yet exposure to the weather for two years suffices to make the blocks as black externally as the limonite from the oxidation.

(5) The limestone ledges in view about an ore pit are not fair examples of the ferriferous limestone that has afforded the ore. They contain little iron, or none, and resist decay; while the more ferriferous has disappeared through the oxidation process and the dissolving action of passing waters, or all except clay, sand, etc., from its impurities.

(6) The distribution of the more ferriferous limestone in the ordinary limestone is exceedingly irregular, and the passage between the two usually abrupt; it exists here and there in patches, large or small, broad or narrow, deep or shallow, continuous or interrupted. Toward the northern end of the Amenia

ore pit the limestone stratum dipping southward passes beneath the slate that makes the east wall; toward the bottom its place is occupied for a while by ore; then in the same line the limestone stratum exists again in a short eroded ledge, externally rusting; and then, again, beyond the ledge, the ore occupies the place of the limestone.

(7) The great space which is occupied by the ore deposit and which is often 100 feet or more deep, is not commonly a previously made cavern; it was made by the dissolving away and removal of the limestone as the oxidation went forward. Were the iron derived from the slate or schist no large cavity would be formed, because of the great amount of insoluble material in the schist; and the ore, instead of being pure ore often through depths of 40 feet or more, would be mixed with three or four times its weight of clay. Where derived from the slate, the fact is indicated by the amount of intermixed clayey material, if not also by much half decomposed slate or schist in place.

(8) The ore derives its cavernous character and looseness of aggregation *not* from the difference in the atomic volume of the oxide and the iron carbonate, but from the method of its formation out of the ferriferous limestone; it sometimes makes a crust about the limestone and along its fissures, which crust thickens within and finally, in many cases, encloses a small cavity, the contained limestone being removed by solution, unless impurities remain (clay or sand) to occupy it in part; and in the process the cavity sometimes becomes hung with stalactites. Often also there are concentric crusts made within the limestone.

(9) The clay of the ore pit is generally in the position of the slate or limstone from which it was derived, only slipped somewhat out of place over the ore in many cases, owing to the displacements going on in consequence of the oxidation and removal of the limestone, as is well described by Professor Lesley. A limestone layer is sometimes of full thickness at one end and much compressed at the other from the oxidation and decay there in progress and the pressure of overlying material.

(10) The decomposition of the slate has been promoted by the carbonic acid set free in great quantities by the oxidation of the iron; the carbonated water so made carried away the potash and other protoxide bases from the mica and feldspar, and left the clay (hydrated silicate of alumina) with much undecomposed mica.

(11) The slate or schist of the region contains but little pyrite or other iron-bearing materials to add to the ore of the deposit, yet sometimes enough of pyrite to make the miners avoid the ore which lies near the schist wall of the ore-pit because of the amount of sulphur in it.

The above conclusions the writer has deduced from his observations. The view he is disposed to favor as to the origin of the irregular ferriferous areas in the limestone formation is as follows:

The stratigraphical change, in the region, from limestone to

slate indicates that a change took place in the era of their formation from limestone-making seas to mud-distribution seas. During the transition from one to the other, iron was washed down from not distant land, in the state of bicarbonate or a salt of an organic acid, over limited areas of the calcareous deposits. These areas so invaded by the iron-solution during the transition epoch, were within interior seas or basins, or marshes, half shut off from the ocean. The calcareous material wherever receiving the iron-bearing waters became changed more or less completely to ferriferous limestone or ferriferous dolomite, or received pure iron-carbonate; and as such waters would have been very irregularly distributed in the basin or marsh, and of varying amount, the areas so changed should be very irregular in distribution and depth. Where the limestone is in part argillaceous or arenaceous, the conditions here mentioned may have existed through large parts of the era of limestone-making. The fact that the limestone is so largely *magnesian* is good evidence that the condition of a partly confined sea-basin existed at intervals through the era of limestone-making; for the magnesia of concentrated sea waters must have been the source of that of the magnesian limestone or dolomite.

5. *Glacial Studies.* — In volume xxiv of this Journal (p. 146), an abstract was given of a paper by M. F.-A. Forel on the structure and movement of glaciers, in which the growth of the crystalline grains of which the ice consists was insisted upon as the essential point in their history. The same author has recently published (Bibl. Univ., III, xii, 70, July 15, 1884) a paper in which he discusses from a theoretical standpoint the probable distribution of the temperature within the mass of the ice of a glacier. He commences with considering the effect of a single winter upon a considerable mass of ice, extending from higher to lower altitudes, and which is supposed to be initially at 0°, and he constructs a diagram showing the portion, superficial below but extending to the bed of the glacier higher up, which might be supposed to be cooled below 0° in the course of the winter. A second diagram shows the supposed effect of a single summer, indicating the portion, superficial above but extending to the bed of the glacier lower down, which might be expected to be affected by the summer's heat and thus be brought into a melting condition. Uniting the two diagrams a third is constructed showing, by the partial overlapping of the two portions named, first, a lower part, A, along the glacier bed, unaffected immediately by either winter or summer; then a part, B, lower down, reduced to the melting condition by the summer and which will always remain consequently at 0°; a corresponding part, C, higher up than A and like B extending partly over it, into which the winter's cold penetrates but which is unaffected by the summer and which may remain below 0°; finally, a fourth layer, D (entirely superficial), affected both by summer and winter and whose temperature may vary from 0° to considerably below 0°. In a word, the glacier may be

considered as made up of a superficial portion of changeable temperature and a profound portion of constant temperature. As to the probable temperature of the latter portion, the author in considering the upper regions from which the ice descends concludes that the bottom portion may be divided into layers from lower to higher altitudes of temperatures, successively 0°, −1°, −2°, −3° and so on; the final diagram given shows these successive layers divided by horizontal lines (taking in consideration the effect of the earth's interior heat) which the author suggests as the probable distribution of the interior temperature of the ice-mass, and he concludes with the hope that the truth of his theoretical deductions may be tested by experiment.

6. *Sketch of the Geological History of Lake Lahontan*, by Israel C. Russell.—From the third Annual Report of the Director of the U. S. Geological Survey. This important memoir, now issued as a separate paper, has been noticed in the preceding volume of this Journal (p. 67). It is illustrated by a map, engraved plates, and two fine heliotype plates, one of a remarkable group of the crystals of the pseudomorph named by King "thinolite."

7. *Geologische Briefe aus America an Se. Excellenz Herrn Dr. H. von Dechen.*—These letters by the German mineralogist, Professor vom Rath, contain some of the results of his observations during a recent journey, extending over about a year, through the United States and Mexico. They are marked by the same keenness of observation and vividness of description which characterize the writings of the same author from Sicily, Syria, Palestine and other countries. Some of the localities spoken of in the letters are Colorado, especially the region about Pike's Peak, Virginia City and Nevada, the Yellowstone Park, and Mexico, including Pachuca, Cordova, Zacatecas and Guanaxuato. When in Mexico he ascended nearly to the summit of Popocatepetl and the account of this trip is full of interest; he also visited the locality at which tridymite was first found in Mexico by Castillo, and gives some valuable notes about it. A list is given, with explanatory remarks, of the many fine and rare minerals found in the neighborhood of Guanaxuato.

8. *On the Composition of Herderite;* by J. B. Mackintosh. (Communicated in a letter dated Oct. 14.)—In regard to the question as to whether the loss on the ignition of herderite is due, as claimed by Winkler (see October number), to the presence of water and not fluorine, I have proved to my own satisfaction that fluorine is present by etching glass; and I am inclined to think that the cause of the loss in weight on ignition is due to the loss of fluorine, it being replaced by oxygen. Although I have not made any quantitative experiments to test the truth of this assumption, yet by comparing the relative etching power of the herderite before and after strong and prolonged ignition, I am satisfied that such a loss of fluorine actually takes place. In one case when I ignited a portion, finally fusing it until it had lost

6·03 per cent in weight, and testing the pulverized residue for fluorine, I could not succeed in etching glass perceptibly, while an equal amount of herderite under the same conditions rendered the glass rough to the touch, besides being very plainly visible at the etched spot. The theoretical loss, assuming that all the fluorine is replaced by oxygen, taking the formula deduced from my analysis as correct, would be 6·75, which is near the figures found by Dr. Winkler. I find, however, that it is very difficult to increase the amount of loss after the first heating. Probably because an enamel is formed on the surface, which prevents the further action of the air and aqueous vapor.

9. *Stibnite from Japan.* — A short paper was recently read (June 17, 1884) before the "Gesellschaft naturforschender Freunde" at Berlin, by Mr. Wada of Tokio, on some Japanese minerals, viz: on pyrite, chalcopyrite, stibnite, topaz and others. In regard to the magnificent crystallized stibnite of Japan, he remarks that the true locality is the antimony mines at Ichinokawa, in the town Ojoin-mura near Saijo, Province Iyo, Island Shikoku. The locality given in the article on page 215, vol. xxvi, of this Journal, is consequently to be corrected; as explained by Mr. Wada, "Kosang" in Japanese means "mine," "Jaegimeken Kannaizu" means "Chart of (the district) Jaegime, or better, Jaechime."

10. *Flora Brasiliensis*, fasc. XCIII.—This makes the larger portion of vol. vi, part 3, contains the tribes of *Compositæ* from the *Helianthoideæ* to the "*Ligulatæ*" (a new name for the *Ligulifloræ* or *Cichoriaceæ*), and so completes Mr. Baker's task in elaborating the *Compositæ* of the Brazilian empire. A large piece of work, to all appearance carefully done.

The great Brazilian region seems to hold its normal quota of *Compositæ*, namely, the tenth part of the Phanerogamia. According to the reckoning, it has 1280 species (the naturalized weeds included), in 150 genera: not so rich as North America, in which we count 237 genera and over 1600 species. In character the Brazilian representatives of the order differ almost as widely from those of North America as from those of the Old World. This prominently appears in the statement that more than one-third part of the species belong to the three genera *Vernonia*, *Eupatorium* and *Baccharis*, and that the genus next in size is *Mikania*. Thus *Eupatoriaceæ* have a prominence to which there is no parallel. All these genera indeed are fairly represented in North America, but only one of them in Europe, and that very scantily. *Vernoniaceæ* may be said to take the lead, having 24 genera and 289 species; in North America, only 3 genera and 10 species. *Eupatoriaceæ* have fewer (17) genera, but 335 species; in North America 15 genera and 111 species. Then come the *Helianthoideæ* with 40 genera but only 221 species, which falls below the North American 64 genera and 337 species; and *Asteroideæ*, with 14 genera and 183 species; while North America has 33 genera and 462 species. The

Mutisiaceæ, almost all American, are very prominent in Brazil, 18 genera and 99 species. The *Inuloideæ*, a weak tribe in America, with 13 genera and 40 species in Brazil, holds there about the same rank as in North America. The meagre tribes are the *Senecionideæ* (only 3 genera and 58 species), *Helenioideæ* (only 9 genera and 30 species, while North America has 43 genera and 214 species), and especially those largely Old World groups, *Cichoriaceæ*, with only 4 genera and 14 species; *Anthemideæ*, with only 4 genera and 6 species, and two of these Old World weeds; and above all *Cynaroideæ*, of which there is only, a single indigenous species, a *Centaurea*. The *Compositæ* of this flora are illustrated by 210 plates. A. G.

11. *Trilisa* is the name of Cassini's genus; not *Trilisia* as it is printed in the Synoptical Flora of North America, page 113. In the conjectural etymology of this name, Wittstein was unwittingly followed. But the name is evidently an anagram of *Liatris* (from which the genus was severed), as my old friend Mr. Charles Wright points out. A. G.

12. Filipo Parlatore, *Flora Italiana, continuata da Teodoro Caruel.* Vol. vi, parte prima. pp. 336, 8vo. Florence: September, 1884.—It is a great satisfaction that the Flora Italiana which, after the fifth volume was arrested by the death of Parlatore, is now continued by the most capable of Italian botanists, Professor Caruel. The task is to be lightened by the coöperation of two or three of his compatriots. The present volume takes up the Corolliflorous Gamopetalæ, and this part contains *Globulariaceæ*, *Lamiaceæ*, and *Verbenaceæ*, not quite finishing the latter. Generic and specific characters are in Latin. These are strictly *characters* or diagnoses; and, after the synonymy, which is in Latin, all needful particulars follow in Italian. Among them a detailed description of almost every species, not rarely filling a page, so that the species average hardly one to a page. The work, with all its (quite too great) amplitude, now bids fair to be worthily completed. A. G.

13. *The Agricultural Grasses of the United States;* by George Vasey, Botanist of the Department of Agriculture. Washington, Agricultural Department, 1884.—In this compact octavo volume Dr. Vasey, who has long and diligently studied the Grasses, provides a manual for popular use, which seems well adapted to its purpose. He gives descriptions, both fairly readable and fairly scientific, of all the agriculturally important grasses of the country, and some others;—through which, aided by the 120 tolerably good plates, the cultivator and stock-raiser may get to know the principal kinds with which they have to do. An essay on the Chemical Composition of American Grasses, by Clifford Richardson, assistant chemist of the department, is included in this handy volume. A. G.

14. *Descriptive Catalogue of the North American Hepaticæ, North of Mexico;* by Lucien M. Underwood, Ph.D. Separate issue from the *Bulletin of the Illinois State Laboratory.* Vol. II,

pp. 133, 8vo.—A publication like this, which begins with a good bibliography and ends with a good index, might at least have a title-page and a date. Moreover, it deserves a less modest title than that of a descriptive catalogue; for it is really a synopsis of the North American Hepaticæ, with generic and specific characters well worked out. The typography and the whole style are excellent. Here, at length, we have good provision for the popular study of our Hepaticæ, and a foundation for the more elaborate work which the author will undertake. We append the last words of the "prefatory note."

"No attempt has been made to publish new species, the writer believing that too many have already been described from insufficient data, and considering it far more necessary to set in order those already published.

"It is hoped that persons receiving this work will aid the further and critical study of this group by communicating specimens of all the forms found in their own localities." A. G.

III. Miscellaneous Scientific Intelligence.

1. *Heliometer determinations of Stellar Parallax in the Southern Hemisphere;* by David Gill and W. L. Elkin; from the Memoirs of the Royal Astronomical Society, vol. xlviii.—Dr. Gill, shortly after his appointment as Astronomer Royal at the Cape of Good Hope, acquired by purchase from Earl Crawford the four inch heliometer which Dr. Gill had used in observing, for the solar parallax, the opposition of Juno at Mauritius in 1874 and of Mars at Ascension Island in 1877. Dr. Elkin joined Dr. Gill at the Cape, and together they observed between July, 1881, and May, 1883, upon a carefully arranged program nine stars for parallax. The following table contains their final results:

		Parallax.	Probable Error.	Mag. of Comp. Stars.
α Centauri	Gill and Elkin,	+0″·75	±0″·01	7·6
Sirius	" "	+ ·38	·01	7·5
ϵ Indi	" "	+ ·22	·03	7¼
Lacaille 9352	Gill,	+ ·28	·02	7·6
o_2 Eridani	"	+ ·166	·018	6·4
β Centauri	"	− ·018	·019	7
ζ Tucanæ	Elkin,	+ ·06	·019	7¼
e Eridani	"	+ .14	·020	6·4
Canopus	"	+ ·03	·030	8

One of the principal difficulties in the use of the heliometer lies in the difficulty of determining, under varying conditions of temperature, the values of the scale divisions of the instruments. In the large distances measured by the heliometer, these values must be determined with accuracy at the time of each observation. The measurements by Drs. Gill and Elkin upon the star whose parallax was to be determined were those of the distances of the star from two stars situated as nearly as possible symmetrically on opposite sides of the principal star. The distances of these two

stars from each other being regarded as constant, the scale values become at once determinate. Four couples of stars were used in the measures upon α Centauri, and two couples in those upon Sirius and upon ε Indi.

These results have been of such value that the British Government has ordered for Dr. Gill the construction of a seven-inch heliometer by Messrs. Repsolds. It is proposed to use this instrument at the Cape Observatory in the determination of stellar parallaxes. H. A. N.

2. *The Materials of Engineering*, in three parts. Part III. Non-ferrous metals and alloys, by R. H. THURSTON. 575 pp. 8vo. New York, 1884 (John Wiley & Sons).—A very large amount of material has been brought together in this volume. It opens with a chapter on the history and properties of the metals and their alloys, and then goes on to the special discussion of the non-ferrous metals to which the book is devoted, namely copper, tin, zinc, lead, antimony, bismuth, nickel and others; also the alloys, as the bronzes, the brasses, the kalchoids and miscellaneous alloys. The latter half is devoted to the discussion of the strength and elasticity of the metals and alloys that have been mentioned, the conditions upon which their strength depends, and the mechanical treatment of the metals and their alloys. The tables in which the various elements are arranged number nearly one hundred, and they are accompanied by numerous diagrams.

3. *A Treatise on the Adjustment of Observations, with applications to Geodetic work and other measures of Precision*, by T. W. WRIGHT. 437 pp. 8vo. New York, 1884 (D. Van Nostrand). —This is a practical treatise giving a sytematic account of the method of adjusting observations founded on the principle of the mean, with a discussion of the applications especially to geodetic and astronomical work. Numerous examples and illustrations taken chiefly from American sources add to the value of the work. The principal topics discussed are: the law of error, the adjustment of direct observations of one unknown, adjustment of indirect observations, of condition observations, application to the adjustment of triangulation, to base-line measurements, to leveling, and so on.

4. *Meeting of the International Congress at Washington.*— At the meeting of the International Congress recently held at Washington, and at which delegates from twenty-two nations were present, some very important decisions were reached. In the first place, by an almost unanimous vote, the meridian of Greenwich was adopted as the prime meridian for the world; only San Domingo voted in the negative while France and Brazil refrained from voting at all. In the second place, it was voted that longitudes should be reckoned east (+) and west (−) of of Greenwich. Finally, it was proposed to adopt a universal day for certain purposes other than local, this universal day to be a mean solar day, to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day and date of that meridian, and to be counted from zero up to twenty-four hours.

5. *Meeting of the National Academy of Sciences at Newport, R. I., October* 14, 1884. — The following are the titles of the papers entered to be read:

On the theory of atomic volumes: by WOLCOTT GIBBS.
On the complex inorganic acids: by WOLCOTT GIBBS.
Notice of Muybridge's experiments on the motions of animals by instantaneous photography: by FAIRMAN ROGERS.
Report on meridian work at Karlsruhe: by W. VALENTINER.
On the Algebra of logic: by C. S. PEIRCE.
On the temperature of the Lunar surface: by S. P. LANGLEY.
Notice of Grant's difference engine: by FAIRMAN ROGERS.
On Gravitation survey: by C. S. PEIRCE.
On minimum differences of sensibility: by C. S. PEIRCE and J. JASTROW.
Researches on Ptolemy's star-catalogue: by C. H. F. PETERS.
On the operations of the United States Geological survey: by J. W. POWELL.
The motion of Hyperion: by ASAPH HALL.
Remarks on the civilization of the native peoples of America: by E. B. TYLOR.
Some results of the exploration of the deep sea beneath the Gulf Stream, by the U. S. Fish Commission steamer "Albatross" during the past summer: by A. E. VERRILL.
Recent progress in explosives: by H. L. ABBOT.
On the methods of eastern archery: by EDW. S. MORSE.
On the thinolite of Lake Lahontan: by E. S. DANA.
On the Mesozoic coals of the Northwest: by R. PUMPELLY.
On the work of the Northern Transcontinental survey: by R. PUMPELLY.
On an experimental composite photograph of the members of the Academy: by R. PUMPELLY.
The grasses mechanically injurious to live stock: by WM. H. BREWER.
On the Columella auris of the Pelycosauria: by E. D. COPE.
The brain of Asellus and of the eyeless form Cecidotæa: by A. S. PACKARD.

6. *French Academy of Sciences.* — Professor JAMES HALL has been elected member of the French Academy in the place of the late Dr. J. Lawrence Smith.

7. *The Young Mineralogist and Antiquarian.* — This is the title of a small monthly paper published by T. H. Wise at Wheaton, DuPage County, Illinois, in the interests of mineralogists.

Notices are deferred of the following works:

A Treatise on Ore Deposits, by J. A. Phillips, 652 pp. 8vo. London, 1884 (Macmillan & Co.).

The Reptiles and Batrachians of North America, by S. Garman. Memoirs of the Mus. Comp. Zool., vol. viii, No. 3. 186 pp. 4to, with 10 plates. Published by permission of the Kentucky Geological Survey.

Description of the Coal Flora of the Carboniferous formation in Pennsylvania and throughout the United States, by L. Lesquereux, vol. iii, 8vo. Harrisburg, 1884, Pennsylvania Geol. Survey, Report P.

Ceratiocaridæ from the Upper Devonian in Warren County, by C. E. Beecher; and Eurypteridæ from the Lower Productive Coal Measures in Beaver Co., by James Hall. Pennsylvania Geol. Survey, Report PPP.

The Deposition of Ores, by J. S. Newberry.